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ABSTRACT

This report describes a project consisting of a collaborative effort involving a team of computer graphics specialists and an art historian in creating an electronic facility for teaching and research in the history of art. The major innovation was in finding a way to use exclusively digitized material, text, images, and movement through space, in the classroom. This effort led to the development of an electronic compendium of ideas and facts in an interrelated data bank of images and text (*ECIT*), which can be filled with information on given subject or subjects, and used by instructors and students as a tool for teaching and research. The development of *ECIT* took place during the creation of a relational database covering the artistic career of the 15th century Italian painter Piero della Francesca. Using the compendium created a new kind of interaction between student and instructor that was more free-wheeling, creative, and energetic than the traditional lecture/note-taking interaction. Appendices include: brochure with project description; course description and syllabus; list of faculty visitors; student and visiting-professor evaluations; printouts of the electronic images; dissemination; present and future collaborators; major contributors to the project; three-dimensional software developments; and the database software interface. (SWC)

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The Piero Project

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THE PIERO PROJECT

I. OVERVIEW:

The project consists of a collaborative effort involving a team of computer graphics specialists and an art historian in creating an electronic facility for teaching and research in the history of art. The major innovation was in finding a way to use exclusively digitized material, text, images, and movement through space, in the classroom. This effort led to the development of an electronic compendium of ideas and facts in an interrelation data bank of images and text (*ECIT*), which can be filled with information on a given subject or subjects, and used by instructors and students as a tool for teaching and research.

II. PURPOSE:

Our original proposal stated that, 'This proposal...addresses the use and implications of a new technology" in the teaching of art history. This particular discipline has been limited for more than a century to a simple procedure for displaying visual images: projected slides of still photographs of buildings and objects of art not present. Teaching involves using such slides to convey the works' visual characteristics: 1) subject matter, 2) style, 3) form, 4) color, 5) scale, and 6) context.

Dissatisfaction with the inadequacies and limitations of traditional means and the search for new solutions, brought together a senior art historian (with computer experience; Lavin) and a computer graphics specialist (with art history background; Alexander). Our shared understanding of the problems, and our complimentary skills led us to believe that if we worked together we could solve many issues of visual literacy for large groups of students, other scholars, and other kinds of observers. We knew that computer technology was advanced to the point that good quality photographs and slides could be scanned and stored in workstations at high enough resolution to study 2) style, 3) form, and 4) color as well as if not better than with slides. Moreover, digitizing would solve the problem of preservation.

What became paramount was the more interesting challenge of devising electronic means to retain 5) relative scale, whole/part relationships, and 6) ambient settings more effectively and thoroughly than had previously been achieved.

III. BACKGROUND:

The project came into being just after Lavin had completed a study of the narrative arrangements in Italian fresco cycles. Because such cycles often include as many as 20 or 30 scenes in a sequence, she had created a computer database of nearly 250 examples, and was relatively well-versed in computer technology. While her work was still in progress, she realized that traditional photographs and diagrams were not going to be adequate to illustrate her topic: general views would give a notion of the ambient but would overlook the particulars; photographs taken close up

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from scaffolding would show individual scenes and details, but lose the context and the overall conceptual planning. She sought clear details and good color, but above all, she sought a way to retain context and show the progressive movement of the narratives through large architectural spaces. In her search for alternative methods, she ventured into the Interactive Computer Graphics Laboratory (ICGL) where she met Kirk Alexander, Manager of the Laboratory. As fate would have it, Alexander had majored in art history as an undergraduate, and later did an M.A. in civil engineering before specializing computer graphics.

Kevin Perry, a skilled mathematician and computer graphics programmer, joined the team, providing most of the solutions to the technical problems as they arose. The Princeton University Computing and Information Technology (CIT) administration agreed to lend the necessary computer and man-power time to get started. ICGL has a staff with many years of experience, covering a variety of visualization projects, as well as teaching projects using computer technology in the classroom. There are two "electronic classrooms" at Princeton, one with 20 machines, one with 24. At the same time, the Department of Art and Archaeology gave its joint sponsorship; providing release time, slides, photographs, and documentation. Moreover, several professor in the department favorably disposed toward technical innovation, played key roles in the project as it unfolded.

Its goal soon became the development of a three-dimensional computer graphics program addressing the problems of scale and context, with the aim of using it in teaching the history of art. Within a year, the development had met with spectacular success: we were able to create a spatial environment on the computer screen that pictures the fresco cycle in its three-dimensional setting, retains the context, including peripheral vision, and adequately defines the relative scale of object and ambient. At the same time, the paintings are seen in high-resolution, full-color digitized images set in their three-dimensional architectural ambient through which the spectator's line of sight can move at a natural rate of speed.

IV. EVALUATION

At the beginning, we were convinced our task was to replace traditional and quite unsatisfactory electric equipment with computer technology in order to improve teaching and lecturing. But after we had the new technique in hand and actually taught with it, we were surprised to realize that the compendium rendered the traditional form of lecturing obsolete. Directing the students to search the compendium for works of art under discussion, stretched their minds in ways that brought up not only examples but also brought up new questions. These spontaneously generated queries then led to discussions that took on a life of their own. In effect, using the compendium created a new kind of interaction between student and instructor(s), that was much more free wheeling, creative, and energetic than the tradition lecture/note taking.

There can be no doubt that the project created a "dynamic new instructional technology" and brought it into the classroom. The change is so comprehensive that it is not yet possible to quantify the results in a "before and after" statistical

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comparison. However, one can analyze the increased depth achieved in both classroom discussions and in student projects to appreciate the difference the technology made in the students' learning experiences.

V. SUMMARY AND CONCLUSION:

The three-dimensional software has been the source of continual discovery. Not only is the software itself a major innovation in the teaching of art history, but also it will require serious, long-range, reworking of pedagogical methodology. The course on one Renaissance artist, Piero della Francesca, has become in itself a study of how technology can be integrated with historical material and intellectual ideas in the classroom to achieve what may prove to be new, higher level results. Ten major milestones are listed.

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THE PIERO PROJECT : FINAL REPORT....1
I OVERVIEW:....1
II PURPOSE:....1
III BACKGROUND:....2
IV PROJECT DESCRIPTION:....4
1. Building a three-dimensional graphical framework....4
2. Amassing the material and creating the database of three-dimensional materials to go into the framework described in 1....5
3. Designing the framework to hold a relational database for scholarly and educational art historical material, text and image....8
4. Amassing an analyzing materials for an art history course, and entering them into the frame work....9
5. Integrating the three-dimensional visual data with the textual and still image-data of the relational database....9
6. Giving the seminar Art 430: "Piero della Francesca On-Line"....10
A. Classroom Architecture:....11
B. Lecture/Demonstration Interaction (art historian/graphics specialist):....12
C. Student participation, response, and responsibility:....12
D. Reevaluation of Assignments and Drill Structure:....13
V EVALUATION:....13
VI. SUMMARY AND CONCLUSION:....15
APPENDIX 1: BROCHURE....17
APPENDIX 2: VIDEO....18
APPENDIX 3: COURSE TITLE, DESCRIPTION, SYLLABUS: PIERO DELLA FRANCESCA ON-LINE:....19
APPENDIX 4: LIST OF FACULTY VISITORS TO ART 430....21
APPENDIX 5: EVALUATIONS....23
A. Students comments (June 1994):....23
B. Visiting Professor Comments:....23
APPENDIX 6: VISUAL PRODUCTS (from ART 430)....25
APPENDIX 7: DISSEMINATION:....43
A. Video Copy Presentations to date:....43
B. Two television appearances (NJNET and BBCV)....43
C. Piero colloquium at the National Gallery of Art, Washington, DC. 12/92....43
APPENDIX 8: PRESENT AND FUTURE COLLABORATORS:....45
APPENDIX 9. MAJOR CONTRIBUTORS....46
APPENDIX 10: THREE-DIMENSIONAL SOFTWARE DEVELOPMENT:....47
APPENDIX 11: DATABASE SOFTWARE INTERFACE....49

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THE PIERO PROJECT : FINAL REPORT

I OVERVIEW:

The project consists of a collaborative effort involving a team of computer graphics specialists and an art historian in creating an electronic facility for teaching and research in the history of art. The major innovation was in finding a way to use exclusively digitized material, text, images, and movement through space, in the classroom. This effort led to the development of an electronic compendium of ideas and facts in an interrelation data bank of images and text (*ECIT*), which can be filled with information on a given subject or subjects, and used by instructors and students as a tool for teaching and research. The development of *ECIT* took place during the creation of a relational database covering the artistic career of the 15th-century Italian painter Piero della Francesca. After ten months of preparation, *ECIT* was used in a workstation classroom to teach a monographic seminar on this artists to a group of eight undergraduate and graduate students. *ECIT* will soon be ready to be given out as an electronic framework to other teachers and scholars who will fill it with their own material, text and images in digitized form, for use in teaching their own courses.

II PURPOSE:

Our original proposal stated that, "This proposal...addresses the use and implications of a new technology" in the teaching of art history. This particular discipline has been limited for more than a century to a simple procedure for displaying visual images: projected slides of still photographs of buildings and objects of art not present. Teaching involves using such slides to convey the works' visual characteristics. Some of these characteristics are: 1) subject matter, 2) style, 3) form, 4) color, 5) scale, and 6) context.

1) Subject matter is quite easily understood from still photographs and slides. 2) Style, which can never be fully analyzed outside of contact with the original, can nevertheless be more or less adequately observed in detailed photographs. 3) Form in painting is ably recreated in photographs; in three-dimensional sculpture, however, form is obscured, since only one view at a time can be seen. 4) Color in reproductions depends on the quality of the camera, the film, and developing process; after photographs have been reproduced as slides, the quality depends on their state of preservation. Under the best of circumstance, slides have a relatively brief "shelf life." Exposed to light, the color deteriorates fairly rapidly; many slide collections begun forty or so years ago now have holdings so drained of color as to be almost without value. 5 and 6) Both scale and context present the most serious problems in reproductions. Projected on a screen, all 2" x 2" slides come up at the same size. Thus, a tiny manuscript illumination will frequently seem as big as a monumental sculpture. Absolute dimensions are often difficult to ascertain and few instructors have the time to correct the impression given by the projections. Communicating context is even more complex. There are at least two aspects: one is the relationship of parts. Unless one is quite familiar with the total work, details photographed independently can lose their relationship to the whole. In fact, details are often

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photographed with the intention of creating the illusion of an autonomous entity. An example would be one tier of a fresco cycle, or one panel of a predella, where the fictive border frames the detail, as if it were are work of art in its own right. The other aspect is context in the sense of ambience. Reconstructing the setting in which a work of art originally existed is usually a matter beyond the scope of anything but specialized research. As a result, objects and parts of objects are frequently shown as though in a vacuum, divorced from surroundings with which they were intended to interact. The problem is greater in other cases where the ambience is actually part of the work of art (as with architectural sculpture, mural paintings or mosaics): traditional techniques are barely adequate for displaying the three dimensional space of real architecture, for defining how objects are arranged in space, and very often even for demonstrating two-dimensional imagery that represents three-dimensional space. Only by seeing where parts exist on or in the building, to what they are related, and how, can their aesthetic, iconographic, or symbolic meanings be appraised. Yet, it is precisely slides of general views, which show the ambient but no details, or of details, which lose the context, that traditionally fill the screens of art history lectures. To conteract all these shortcomings, instructors often are forced to spend valuable class time on simple description rather than assuming visual parity with the students and being able to proceed directly to deep analysis and intellectually stimulating discussion.

Dissatisfaction with the inadequacies and limitations of traditional means and the search for new solutions, brought together a senior art historian (with computer experience: Lavin) and a computer graphics specialist (with art history background: Alexander). Our shared understanding of the problems and our complimentary skills led us to believe that if we worked together we could solve many issues of visual literacy for large groups of students, other scholars, and other kinds of observers. At the simplest level, we knew that computer technology was advanced to the point that good quality photographs and slides could be scanned and stored in workstations at high enough resolution to study 2) style, 3) form, and 4) color as well as if not better than with slides. Moreover, digitizing solved the problem of preservation. Once in the machine, images would not longer deteriorate or change color on their own. At first, there were some rudimentary problems to deal with: namely scanning the images into the computer (app. 8 minutes of man-power time each); identifying the scans properly for storage and retrieval (standardized vocabulary issues). But they were easily solved. What became paramount was the more interesting challenge of devising electronic means to retain relative scale, whole/part relationships, and ambient settings more effectively and thoroughly than had previously been achieved.

III BACKGROUND:

The project came into being just after Lavin had completed a study of the narrative arrangements in Italian fresco cycles. Because such cycles often include as many as 20 or 30 scenes in a sequence, she had created a computer database of nearly 250 examples, and was relatively well-versed in computer technology. While her work was still in progress, she realized that traditional photographs and diagrams were not going to be adequate to illustrate her topic: general views would give a notion of the ambient but would overlook the particulars; photographs taken close up

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from scaffolding would show individual scenes and details, but lose the context and the overall conceptual planning. She sought clear details and good color, but above all, she sought a way to retain context and show the progressive movement of the narratives through large architectural spaces. In her search for alternative methods, she ventured into the Interactive Computer Graphics Laboratory where she met Kirk Alexander, Manager of the Laboratory. As fate would have it, Alexander had majored in art history as an undergraduate, and later got an M.A. in Civil Engineering before specializing in computer graphics. Although he was fully cognizant of the need for a new approach in art history, he could offer little help at that time; the laboratory had no equipment that could accomplish the desired tasks, and he advised Lavin to publish her book with traditional means.

Three years later, ironically just a few months after Lavin's book came out, the ICGL acquired a Silicon Graphics IRIS VGX workstation. The full potential of the machine was not known at the time, and the Laboratory was looking for projects with which to try its facilities. Recalling the problems Lavin had earlier posed, Alexander contacted her to inquire if she were still interested in exploring the issues they had previously discussed. Following that meeting, their cooperative venture was launched. Kevin Perry, a skilled mathematician and computer graphics programmer, joined the team, providing most of the solutions to the technical problems as they arose. The Princeton University Computing and Information Technology (CIT) administration agreed to lend the necessary computer and man-power time to get started. The ICGL has a staff with many years of experience, covering a variety of visualization projects, as well as teaching projects using computer technology in the classroom. There are two "electronic classrooms" at Princeton, one with 20 machines, one with 24. At the same time, the Department of Art and Archaeology gave its joint sponsorship, providing, release time, slides, photographs, and documentation. Moreover, several professor in the department favorably disposed toward technical innovation, played key roles in the project as it unfolded.

Because of Lavin's specialization in the study of Italian fresco painting in general, and the paintings of Piero della Francesca in particular, we decided to concentrate on this artist. Because of Alexander's expertise in three-dimensional computer grapnics, and the advent of the powerful new workstation in the laboratory he oversaw, we decided to focus on Piero's one great work which is fixed in an architectural setting: the fresco cycle of the True Cross in the church of San Francesco, Arezzo (1452-1466), where the paintings appear on three walls of the rectangular main apse.

The Piero Project, as it became known, then began with the mission of investigating what the VGX could offer the study and analysis of a large scale work of art in its spatial context that traditional still photography and 35 mm slides could not. Its goal soon became the development of a three-dimensional computer graphics program addressing the problems of scale and context, with the aim of using the it in teaching the history of art. Within a year, the development had met with spectacular success: we were able to create a spatial environment on the computer screen that pictures the fresco cycle in its three-dimensional setting, retains the context, including peripheral vision, and adequately defines the relative scale of object and ambient. At the same time, the paintings are seen in high-resolution, full-color digitized images set

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in their three-dimensional architectural ambient through which the spectator's line of sight can move at a natural rate of speed.

During the development of this model, a need to enrich the three-dimensional visual program with textual material became apparent. First, we realized that a reconstruction of this complex work of art would profit as a teaching tool by the addition of documentation and analysis. Second, our success with one work of art led us to believe that the electronic compilation could be enlarged to include the entire oeuvre of the artist. To test the feasibility of these ideas, the team was expanded to include a relational database expert. The project then shifted its emphasis to creating a custom computer framework to hold scholarly and educational material and to the amassing of scholarly material and its reformulation for entry into the framework. The progressive success of this endeavor made it possible to envision a full semester course in Renaissance painting, using nothing but electronic teaching equipment. The final phase of the project was the actual teaching of the seminar, made up of fifteen three-hour sessions with students, in the Spring of 1994 (See Appendix 10 and 11, for technical comments)

IV PROJECT DESCRIPTION:

The work of the project can be described as having six parts:

1. Building of a three-dimensional graphical framework for reconstructing works of art, the ambiance of which is an integral part of the work itself.
2. Amassing the material and creating the database of three-dimensional materials to go into the framework described in 1.
3. Designing the framework to hold a relational database for scholarly and educational art historical material, text and image.
4. Amassing and analyzing materials for an art history course, and entering them into the framework.
5. Integrating the three-dimensional visual data with the textual and still image-data of the relational database.
6. Giving the seminar Art 430: "Piero della Francesca On-Line"

1. Building a three-dimensional graphical framework.

Building a three dimensional graphical framework started with gathering the dimensions of the area to be represented: the height, width and depth. Coordinates were established with these figures and a perspective drawing of what is, in the case of the apse of San Francesco in Arezzo, a rather simple rectangular space was rendered in the computer. The reconstruction was accomplished with AutoCAD, a computer-aided drawing application. The procedure, called modeling, produced a transparent structure, or "wire-frame," that encloses the illusion of a realm known as "virtual space." Once the structure was established, the computer was told to fill in the planes to form wall surfaces. Various moldings, decorative elements, and fenestration, were generated with additional modeling utilities.

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2. Amassing the material and creating the database of three-dimensional materials to go into the framework described in 1.

The database of material to be entered into the computer model consisted of photographs of the separate tiers of the frescoes scanned and stored in a computer. The digitized images were transmitted from the scanning computer to the modeling workstation and then appended to the model of the chapel by a process known as texture mapping onto their proper positions on the walls. The result was a three-dimensional digital construction of the entire chapel with its mural decoration seen in correct perspective (Fig 2). Up to this point, we had done what many different kinds of computer systems can do. The next step, however, was unique.

With a custom program created by the Princeton technical team, the workstation made it possible to move the spectator's line of sight around in the virtual space freely throughout the chapel: up, down, sideways, turning, returning, entering into details and backing out again, to observe the paintings from an infinite variety of angles (see Appendix 6). Even though our preliminary images were fairly mediocre and they moved somewhat jerkily, it was immediately apparent that we had a new and very effective tool for viewing works of art, one that would eventually change the way we see, use and relate to surrogate images.

By the end of the first calendar year, the equipment had been greatly reduced in price and greatly improved by a "tool kit" (named Inventor) that did automatically most of the things our programmer had painstakingly accomplished on his own. Although these advances meant that we had to start again, we did so at a much higher level of refinement. We now obtained superior images of the cycle and set to work again, focusing on a number of points. One of the greatest assets of the IRIS workstation with the Inventor software is the ability to emulate human movement. This computer redraws images rapidly at different sizes, producing the effect of coming closer or moving farther away, and thereby changing the spectator's position of viewing. The redrawing takes place at such a rapid pace (approximately sixty times a second), that one cannot perceive the changes, and the result is apparently smooth movement, (in computer terminology "real-time motion"). The change of viewpoint can be directed with the traditional "mouse," which creates movement in two dimensions over the surface of the screen, or with a spherical object, a "space-ball," which creates movement in three dimensions through the represented space. The process of moving the image by hand is known as "interactivity," with the implication that commands given by the user generate instantaneous response by the system.

With these instruments, a viewer looking at the terminal screen, experiences something close to what it is like to enter at will into the church and "walk" down the nave into the apse. He can "turn on the lights" (with a special menu), look around from side to side, and looking up to the top of the walls, as one might move one's head when standing in the chapel. In so doing, he "sees" the wall paintings from a very oblique angle. (It is important to point out that during all such movement, the images are continuously generated in correct perspective.) At this point, he makes use of the unique aspect of the computer, namely, he rises through space to the height of the

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lunettes where, for the first time and with great facility, he attains one of Piero's ideal viewing positions[1] . Not even Piero at work could have seen his frescoes in this manner. The structure of the scaffolding he used is unknown, but two forms seem the most plausible. One form is scaffolding that filled the chapel completely (as was done in the 1961-1963 cleaning campaign); in this case, the painting would have proceeded horizontally, so to speak, one level at a time on all three walls, moving down from top to bottom (because of dripping paint). Currently a campaign of preservation is being carried out by the Ministero delle Belli Arte di Arezzo using the other possible form of scaffolding, that is, covering only one wall at a time; in this case, the painting was carried out by completing one wall from top to bottom, and then moving the scaffold to work on another. In either instance, Piero would never have had a chance to see his work from this level without at least part of the scaffold structure blocking his view. With the computer, by contrast, the viewing station can be suspended out in empty space. The spectator can then, as it were, turn his point of view back and forth across all three walls, float about, arrive at any level, and meanwhile have the entire painted surface remain in his field of vision. In this way the problem of seeing each scene in context is solved. It bears repeating that, in fact, this trait is one of the most important assets of this technology. In providing a visual range that far surpasses traditional reproductive media, the program helped reveal important juxtapositions and relationships that might be missed when looking at separate photographs of individual scenes. Seeing the relationships in this manner serves to stimulate new observations, which in turn bring up new questions ultimately asked in new ways.

Another important element was achieving high resolution, or clarity of the image in the computer. During the scanning, the image is broken into a number of illuminated cells called pixels (picture elements); the more pixels per unit square area, the higher the resolution. In this context, however, it should be remembered that Piero's frescoes are in deplorable condition, having suffered severe losses over the centuries in color intensity. A new photographic campaign, impossible in any case because of the conservation work in progress, would sadly only document their deterioration. For this project, therefore, we turned to the best color slides and transparencies available; they dated from 1970s. After scanning transparencies in a flat-bed scanner proved unsatisfactory for various reasons, we made 35 mm slides from the transparencies and scanned them in a slide scanner with much greater success. The digitized images were then preserved in the workstation, and retained in a relatively high level of quality. The real frescoes may continue to deteriorate, or may perhaps be preserved by the current scientific campaign. But the digitized images will not change.

Early models of the our workstation could not move images in high resolution. Because of technical limitations, in any given journey, the crispness dissolved and the movement proceeded with visible jerkiness. Only when the movement stopped could the machine refresh the screen, or "re-paint" the images, once more in high resolution. In the second phase of our work, however, this problem was solved. Using a more advanced version of the workstation called the "Reality Engine," operating with the same software, the images now retained high resolution during flight, while moving freely around the three-dimensional space, with no shift of focus upon coming to a halt.

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[1] In the fresco cycle at Arezzo, Piero painted each scene as if it were being viewed head on even though the scene might be 45 feet in air.

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This technical advance was very important for the quality of the visual experience.

As the line of sight roves across the space, pauses can be effected for prolonged observation whenever desired. At any chosen place on the surface, one can "pick" with a mouse click and open a window on a particular area. Within this area, it is possible to "pan" about and see details with great clarity (Fig 3). A number of lighting effects can be called up, either as a generalized illumination or as spot lighting to single out the specific detail (Fig 4). Auxiliary images can also be embedded under the texture mapped surface and called up for inspection in other windows, superimposed on the primary image (Fig 5). These added images can be details of surface elements at higher resolution. They can be material that really is under the surface, such preparatory techniques (underdrawings, incisions, pouncing, giornate joins), or changes (pentimenti). Or they can be figures from outside the primary visual database, ancillary material for use in making comparisons. The embedded images are brought up to the surface again by clicking the mouse button. They can be placed on the screen so that they appear side by side, as in a traditional slide comparison. They can be flipped or reversed, cut out, or superimposed, if that is what the analysis indicates. The size of the images can be scaled in proper proportion, and they can be placed on the screen in such a way that the general context on the wall remains visible.

Any of the images that appear on the screen-- general views, details, corners, juxtapositions, angle shots--can be printed out as glossy hard copy in full color or in black and white.

Another tool offered by the workstation is the generation of geometric diagrams both in two dimensions, on the surface of the picture plane, or in three dimensions, defining solid geometrical relationships. By overlaying painted forms with lines and the representation of planes, relationships of distant parts of the composition can be emphasized and analyzed with alacrity (Fig 6). Because of the ease and speed of such procedures, one is encouraged to test such ideas and perceptions. Mistakes and false starts are easily removed and successes can be preserved and saved in separate files for future use or printing out.

The internal working of the Silicon Graphics tool kit recognizes the identity and orientation of wall surfaces. By clicking the mouse button on any of the walls of the chapel, the computer will take the line of sight to a position that views that wall head on. For example, if we are stationed up in the air, facing the second tier on the right wall, and we wish to see the lowest tier on the left wall to make a comparison, a click of the mouse button will make the complicated move, swinging us around and down in one continuous motion. This automatic maneuver would allow analysis to continue without the distraction of interactive manipulation.

To prearrange a series of such moves around the chapel, with pauses at preordained locations, Kevin Perry devised a method for chaining the travel. Visible markers (combining a cone, indicating a position in space, and an arrow, indicating the direction of movement) enable the line of sight to move to a chosen position (see Fig 3). It is possible to program a series of moves in advance, evoke a menu that removes the markers from sight, initiate the travel, and then be quite free to

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concentrate on extended study and discussion while the computer does the rest. Whether moving the viewing position by hand interactively or using chained travel, the result is vastly superior to anything that could be achieved with single, stationary slides.

3. Designing the framework to hold a relational database for scholarly and educational art historical material, text and image.

Although we continued to develop other ramifications of the interactive three-dimension viewing tool (see below), we moved on to the third phase of work, namely designing a framework to hold a digitized archive of all Piero's paintings, isolated frescoes, panel paintings, and altarpieces, dating between 1445 and 1492. The archive includes comparative images by other artists, and including factual and analytical material to support and expand the substance of the spoken lectures. The supporting material was not thought of as a simple appendage to annotate the visual elements, but would have its independent existence, offering a basis for other forms of dialogue. This structure developed into *ECIT*, our name for the Princeton team's user interface to the database, designed to be easy to use by students and other users with minimal computer skills (see Appendix 11).

The essential challenge in creating this structure was to make it reflect the innate interdisciplinary character of art history. *ECIT* was designed to situated historical facts and images in their proper historical, physical, biographical, religious, political, social, and philosophical context.. Such an undertaking required close cooperation between scholar and technical staff, first in term of communication and vocabulary and then in terms of research. To fulfill the requirements, a serious understanding of the substance of the course, as well as the teaching methodology to be employed, was vital to the designers of the database. The historian and the database analysts therefore discussed the activities of art history in an attempted to discover its quintessential elements. These were interpreted as: a number of assertions about historical evidence concerning specific works of art that form a corpus of study. The assertions themselves fell into several categories:

1) ARTIFACTS:
a) unique identification of a given work (its title, creator, location, dimensions, etc.)
b) its component parts (episodes if a narrative, scenes within a overall composition, details, etc.); all the entities in 1a and b were called artifacts.

2) PEOPLE:
A cast of players, individuals and groups, in some way involved in the creative process (as creator, commissioner, donor, programmer, person represented, etc.); people was the title given to this category.

3) CONTENT:
Other assertions concern the subject matter of a given work:
a) elements actually visible,
b) the interpretation of those elements (their meaning or significance at a given time

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and place; iconography)
c) certain themes expressed by the work that localize it to a given set of ideas; iconology). These elements were categorized as content.

4) CONTEXT:
The final category of assertions is historical and conceptual, and places the work in its proper chronology, geographical and ideological position;it is generalized with the term context.

Often assertions about artifacts, people, content and context, relate to one another as a tree of information, with root, trunk, branches and leaves. Others may be construed as bringing together or linking disparate concepts. Ideally, an art historical presentation offers a narrative of word and image that illuminates an historical event. For full expression of the art historians work, the electronic vehicle had to illustrate the artifacts and capture both the substance and form of the assertions while showing the interrelation between them.

The *ECIT* interface presents a screen with four tables that can be browsed and searched in multiple modes, separately or together. The Artifact Table combines color thumbnail images and text in each entry (Appendix 11). A click of the mouse button on the thumbnail image in the entry brings up a larger-scale version of the same image, which can be edited in various ways. The framework calls for standard catalogue information for all the works of art involved, and links every image to all the personalities and ideas in the other three tables. The links are defined verbally.

4. Amassing an analyzing materials for an art history course, and entering them into the frame work.

In the fourth phase of the project, we used these definitions as guide-lines, to sort Lavin's thirty years of research and publications on Piero della Francesca into the relevant *ECIT* categories. Again analytical discussions and clarification concerning both categories entries and links were necessary. Although somewhat trying, all such discussions were useful and productive to all members of the team. A labor-intensive period followed, during which the information was keyed in to *ECIT*. The immediate objective of this exercise was to prepare for our classroom activity. The richer the compendium became, however, the more the team realized how receptive and responsive the structure was. We had a created a framework that would receive material from any subject in the humanities that uses visual images. Our long term goal now became a reality. We would show our own product as a model and be able to offer the framework to others for their own projects.

5. Integrating the three-dimensional visual data with the textual and still image-data of the relational database.

The fifth phase of the project might be considered in its infancy. The concept involves making *ECIT* accessible on the same platform as the three-dimensional real-time viewing mode, with interaction between the two. To achieve such a

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connection would give the viewer the possibility of triggering database queries by making selections in the three-dimensional window. To ask a question about an image or images in the three-dimension model, one would pick with the mouse on a spot in the model, and receive a response in the artifact, people, content and/or context table(s). We have already succeeded in putting the database and the model into operation on the same screen, and have begun to pose questions. We are also planning to provide text passages embedded under certain areas of the cycle where the iconography or other interpretive aspects of the subject are complex or obscure.

6. Giving the seminar Art 430: "Piero della Francesca On-Line"

In the spring term of 1994, we offered a one-semester university seminar serviced entirely by electronic equipment; that is, art history was taught and no slides were used. For the class, called "Piero della Francesca On-Line," the prerequisites were a course in Renaissance Art or a survey course that included the Renaissance, and the ability to log on to a computer (see Appendix 3). Eight students enrolled ranging from undergraduate freshmen and seniors, to more advanced graduate students. Only one of the students had previously used a workstation; none had ever thought of using such equipment to study art history; none had any database experience.

Although sponsored by Princeton University's Department of Art and Archaeology (McCormick Hall), lectures were held in the Engineering Building where there are two "electronic classrooms." Our class was in a room with twenty SGI workstations mounted on five thin wide tables, four to a row, all facing toward a stage-like platform with a large screen and an overhead projector. Each student sat at his/her own workstation on which he/she was taught to manipulate *ECIT*. There were always at least two technical advisors and assistants present to help. All but one, the oldest graduate student and the only one completely lacking in computer experience, learned to handle the equipment with alacrity.

In a traditional art history lecture, the teacher will turn out the lights and present a sequence of slides to members of the audience who sit passively and take notes. Time permitting, there may be a question period. In our seminar, this procedure was abandoned. Lavin told the students the subject (key words) of the day and asked them to find the images in the computer. The students had to search for supporting information and facts as the lecture proceeded. Alexander often guided the searches on the Reality Engine, the images from which were projected on the screen at the front of the room. While the new technique was somewhat intimidating to a few of the students, in less than two weeks it had become transparent to most of them, and was acting as a stimulant to further visual and intellectual exploration.

Meeting once a week for three hours, for thirteen weeks, each session combined straight academic lecturing, discussion, and instruction on the use of the electronic equipment (including the workstations, *ECIT*, scanning equipment, Photoshop, AutoCAD, the Reality Engine). Lavin lectured and led the discussions; she prepared bibliographies, gave out assignments, administered quizzes, and devised subjects for term papers and research topics. Alexander followed the verbal argument with images, demonstrated searches on *ECIT*, explained the structure and use of the databases, created geometric diagrams, and manipulated the three-dimensional

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viewer. Each session was attended by one or more outside art historian, professors, museum researchers and restoration experts (see Appendix 4, List of faculty to visit ART 430).

The mechanics of the course were naturally effected by the technology. The data bank made available from the beginning the full inventory of all the images that illustrate the course. These images and their captions could be studied on most the 26 clusters of computer workstations on the Princeton campus, using the Internet Mosaic program (Fig 7a, 7b). The data bank further offered a searchable gathering of all facts and ideas involved in the course. Because of the flexible and far-reaching search facility of *ECIT*, students could study, explore, and review the relationships between all the works of art, the people, the ideas, the concepts, and the historical circumstances discussed in the course. *ECIT* also contains a full bibliography which could be searched and printed out at any time, and used for further study and research.

These innovations led to a reinterpretation of student examinations. Quizzes often took the form of on-line searches performed by the students at the front of the class on the Reality Engine. Term papers took on a new form. Working singly or in groups of two or more, the students were given subjects that tested their skills in art historical library research along with the use of the electronic compendium. They were asked to assemble certain groups of art objects using traditional research methods, bring them together, and then exhibit their skills in scanning, entering data, and manipulating images on the terminal screen. For example, they reconstructed complex polyptychs, the parts of which were dispersed centuries ago; they reinvented frames for church altarpieces now in museum in false supports; they recreated fresco cycles in three-dimensional models, and drove through the models in three dimensions to study the paintings. They were asked to identify and analyze new facts and images, and taught to enter them into the database to become a permanent part of the compendium. They all were also required to produced written papers that described their research and defined how they had exploited the new equipment . (See Appendix 5, Student Evaluation, where the new breadth of learning, and the classroom experience is commented upon; and Appendix 6 Visual Products.)

While the course as such was a great success, our instructional techniques were, to say the least, exploratory. We feel there is still much to do to develop them to their fullest extent. The momentum we gained "class was recognized by the host department (Art and Archaeology, Princeton University) and we have been invited to teach the class again (at the University's expense), in 1995, during which we will continue to analyze and develop the following "in class" techniques:

A. Classroom Architecture:

Traditionally, a classroom consists of rows of seats filling 7/8 of a space, and an area at one end of the room where the teacher/professor holds forth. In art history, there is usually one or two screens at one end, onto which 35 mm images are projected by slide machines, run by the teacher by remote controls or by another person (a slide runner) operating the machines. The slides will have been mounted in an unalterable sequence before the class begins. In an electronic classroom these iron-bound relationships are no longer operative, and in fact the architecture of such

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rooms, the placement of machines and wiring and of screen (if any) must be reinvestigated from the bottom up. Students seated behind workstations will not longer focus solely on the front of room; and the professor in the front of the room cannot see what is on the students' screen. Thus the shape of the room, the locations and directions of the machines and over-head screen, and the movement of the teacher must be re-evaluated.

B. Lecture/Demonstration Interaction (art historian/graphics specialist):

A major element in the seminar, as taught, was highly coordinated team teaching; that is, the professor lectured and called upon the students to locate images and textual information in the database, while the graphics specialist drove a "master" workstation with projection on a large-scale screen to display illustrative material. This "pas de deux" required synchronized preparation, plus sensitive understanding of each other's skills. An issue for investigation is whether it is feasible always to expect two people to work together in the electronic classroom; is it possible to imagine one individual doing both jobs; and what kind of staffing does this technique imply? Our experience showed that before such decisions can be made, further analysis must be done in the following areas:

1. Methods of delivering art historical material in a logical manner, while guiding students through the database AND toward recording their findings.

2. Refinement of coordination between the lecture and the demonstration workstation projecting certain images on a large scale screen. Investigation of modalities of driving the demonstration machine by a graphics specialist or, at certain moments, by the lecturer while the graphics specialist personally assists students at their own monitors.

3. Investigation of the possibility of the demonstration machine moving the program on student terminals, as a guide to their research in class; this is a technical issue.

C. Student participation, response, and responsibility:

The idea of teamwork is new to art history. Up to now scholars as well as students have tended to work alone, even secretly until they are ready to publish. Yet as art information expands and become globally transferable, more cooperation will have to evolve. The classroom is a model environment in which this development can begin. To initiate these new concepts, we must:

1. Invent methods for students, as they use the database in class, to communicate their findings to the other students, as a form of information, and as stimulus for further discussion.

2. Define new methods of invoking verbal participation and discussion of lecture material in relation to reading assignments, while watching and searching images on the screen.

3. Teach techniques for distilling and editing student information, and teaching them

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to enter it (when appropriate) into the database "on the fly".

D. Reevaluation of Assignments and Drill Structure:

The new electronic facility will bring new forms of research. Therefore, we must seek:

1. Integration of art historical library research into classroom discussions to enrich data already entered into the database.

2. Redefinition of quizzes, exams, and papers to match the electronic mode. Investigation of new subjects combining research in primary and secondary art history (written) sources, digitized imaging (constructions, reconstruction, analyses, comparisons), and personal contribution to the ideas.

V EVALUATION:

When we began our project, we were convinced our task was to replace traditional and quite unsatisfactory electric equipment with computer technology in order to improve teaching and lecturing. But after we had the new technique in hand and actually taught with it, we were surprised to realize that the compendium began to render the traditional form of lecturing obsolete. Directing the students to search the compendium for works of art under discussion, stretched their minds in ways that brought up not only examples but also brought up new questions. These spontaneously generated queries then led to discussions that took on a life of their own. In effect, using the compendium created a new kind of interaction between student and instructor(s), that was much more free-wheeling, creative, and energetic than the traditional lecture/note taking.

There can be no doubt that the project created a "dynamic new instructional technology" and brought it into the classroom. The change is so comprehensive that it is not yet possible to quantify the results in a "before and after" statistical comparison. However, one can analyze the increased depth achieved in both classroom discussions and in student projects to appreciate the difference the technology made in the students' learning experiences. One simple (and quantifiable) observation is that students in this course were presented material through a much larger number of tools than in any previous art history course. This opulence gave them several perspectives on each topic and even allowed them to "push ahead" of the presented material and test ideas of their own. For example, they could search *ECIT* and make image comparisons of their own choosing in addition to following those being presented by the instructors. They could track down an alternate iconographic theme and ask questions that might totally change the direction of the classroom discussion. The database was designed to provide quick access to key ideas (instead of long self-explanatory textual passages). These ideas form the stepping stones around which discussion evolved. As a result, what might have been a traditional art history lecture format became more like a live experimental laboratory. With *ECIT* at their finger tips, the students had, from the beginning, access to the ideas behind all the analyses that Professor Lavin had developed during her career

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and would present in the class, but not necessarily to their interpretation. In the database, they could observe WHAT was important at their leisure. But to learn WHY, they had to ask questions, discuss in class, conceive their own ideas, or go to the library to do research for further information. This change of dynamic was a significant departure from simply writing down the facts and ideas presented in a professor's lecture and taking them for granted. Because we were able to put so much of the course material on-line and offer so many tools to explore it we created a provocative context on all fronts: array of images, iconographical content, historical context, geometrical analysis, compositional and perspective analysis and, of course, three dimensional inter-relationships (see also Fig 16).

After a semester of experience with the tools in the classroom, we found that the problems had not changed, but that new problems were defined. We needed new classroom architecture, that is a new physical relationship between instructor and student. The lecturer can no longer stand at the "front" of a room and hold court. An oval or a circular arrangement might help; orientation of the machines must be flexible upon installation. The instructor will have to learn a new timing for delivery; material cannot be "presented" to the class. The class members must search for it (in *ECIT*) and must have time to do so; they must discuss it almost before they know what it is; they must "discover" the problems. Teachers will have to search for new kinds of assignments to take advantage of the equipment and new methods of testing skills. We have only begun to see how these new issues can be resolved.

We must emphasize that our contribution to pedagogy, however it develops, differs radically from courses that are now being encapsulated on Compact Discs. CDs have the advantage of transportability, repeatability, stand-alone independence, and wide distribution. The material so assembled, however, is generally predetermined, that is planned and recorded in a finite form, captured on disc and frozen in terms of content and attitude. To make changes, the recording must be completely redone.

What we have created, on the other hand, is an open framework into which can be entered teaching materials from any field in the humanities enriched with visual images. The framework is meant to facilitate teaching without mandating a point of view about the material put into it. It is meant to open teaching and viewing to greater visibility and assurance, while remaining flexible and responsive. The framework becomes a compendium only when it is filled with the information involved in a given subject. Each manifestation, each compendium, will depend on interaction between instructor and student; between student and machine; and between student and student. The compendium remains alive in the sense that additions, deletions, and corrections can be made "on the fly." New entries and emendations, done through an internal program, at any moment in class or out, go into operation immediately, thus allowing both instructor and students to keep an open mind about all the material at hand. *ECIT*, obviously, is not and never will be a teacher-substitute or a "canned course." Instead, the framework has been designed to accommodate and stimulate different points of view. The main caveat is the amount of work it takes to get started. One must rethink familiar material in order to mold it to the categories of the framework. Once the material starts to build a compendium, however, the information is always available, from many points of entry, and within many kinds of relationships. Using the *ECIT* facility will only be deemed successful if it stimulates creativity

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both in teaching and in learning, in the presentation of class material, bibliography, study tools, and in preparing assignment, "papers," and examinations (Fig 8-12).

Such compendia would have the role of delivering materials both fundamental and ancillary to the historian's exposition, along with the possibility of providing a new type of interaction between members of the class and the instructor. Also, since the class will generate it own research, by incorporating the new material, the database will ultimately be available to a community larger than the isolated classroom.

VI. SUMMARY AND CONCLUSION:

The three-dimensional software has been the source of continual discovery. Not only is the software itself a major innovation in the teaching of art history, but also it will require serious, long-range, reworking of pedagogical methodology. The course on one Renaissance artist, Piero della Francesca, has become in itself a study of how technology can be integrated with historical material and intellectual ideas in the classroom to achieve what may prove to be new, higher level results. "Piero On-Line" arrived at the following important milestones:

1. All imagery used in teaching the course was scanned and placed on-line

2. Several examples of architecture and painting were modeled in three dimensions and demonstrated to the students (see Figs 2,10,11,14,15)

3. Three commercial software packages were employed in the course: Adobe Photoshop was used for image scanning and manipulation. Iris Showcase was used for live exploration of geometric relationships in painted compositions. AutoCAD was used to model three dimensional architectural spaces.

4. A client-server database was built of all the major artifact, people, content and context items discussed in the course.

5. The database was accessed by each student in the classroom during each seminar. The entire dynamic of the class was affected by this new study and research tool.

6. The three-dimensional demonstrations, image presentations, database interactions and geometric analysis were all presented live to the students from a workstation connected to a projector in the classroom, responding to spontaneous suggestions and ideas generated in class.

7. Additions were made live to the database during class if missing items were discovered or if the instructors or the students made new observations

8. The database was connected to the three-dimensional viewer. Queries could be initiated by select image in the three-dimensional view and database query results could be displayed on third dimensional context.

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9. Communication with the students outside class was all handled electronically through a "listserv" and e-mail.

10. Student projects were assigned to individual or teams of two or more. The teams were responsible for adding both imagery and relationships (links) to the database. Each project also produced either a new two- or three-dimensional analysis that was both executed and demonstrated in class (in lieu of traditional term papers) using the software made available for the course.

The Interactive Computer Graphics Laboratory at Princeton has recently become part of a slightly larger group known as "Instructional and Media Services" which now supports additional classroom technology applications. The existence of such technical staff resources, and the attitudes they express about technology and education, was important for our project's success. In addition, the rather small size of the university means that the ICGL has been able to serve as the fulcrum for innovative ideas and projects in the electronic realm, with which many other departments have already made contact. It will be through the ICGL, and the experience gained in the "Piero Project" that future work in the realm of electronic teaching and research will spread at Princeton and beyond (see Appendix 7). There is a continuing and growing need to assimilate complex data storage and access methods with sophisticated visualization facilities in many fields of the humanities and other academic areas. A model such as the "Piero Project" can only promote the dialogue (see Appendix 8).

Marilyn Aronberg Lavin, Professor
Art and Archeology Department

Kirk D. Alexander, Manager
Interactive Computer Graphics Laboratory

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APPENDIX 1: BROCHURE

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Seminar Syllabus Outline

1. Introduction: General background on Piero della Francesca; , Orientation in the Interactive Computer Graphics Laboratory; operation of the Silicon Graphics VGX IRIS Workstation;
2. Lecture: Early Career (1432-50), Sansepolcro, Florence, Ferrara; Lab: Instruction in the use of verbal databases and operation of the Flatbed and Slide Scanners.
3. Lecture: Rimini; other youthful works; early Arezzo; Lab: Operation of Custom Software Real-time Motion
4. Lecture and Lab: Arezzo cycle (continued)
5. Lecture and Lab: Arezzo cycle; Rome
6. Lecture and Lab: Arezzo cycle; Magdalene
7. Lecture: Flagellation; Lab: Computer analysis (measuring, three-dimensional geometric diagrams, and exploration of light sources)
8. Lecture: Baptism and Madonna del Parto; Lab: Plain geometry analysis and exploration; spatial analysis
9. Lecture: Altarpieces: Augustine; Antonine; Lab: Computer reconstruction's
10. Lecture: Portraits; Lab: Computer analysis of placement, use of death masks; copies
11. Lecture: Resurrection and Brera Madonna; Lab: Computer analysis of perspective and mathematical spatial construction
12. Lecture: Latest works (Adoration; Senigallia Madonna); Lab: Computer reconstruction; analysis of irrational space
13. Student papers: topics involving collection and scanning of images (Comparative material); creation of personal databases. Oral presentation using workstation to illustrate intellectual findings.
14. Student Papers (continued)
15. Student Papers (continued)

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Developed jointly by

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Professor, Department of Art & Archaeology

Kirk Alexander, Manager
Interactive Computer Graphics Laboratory
Computing and Information Technology

Kevin Perry
Graphics Analyst

Peter Vince
Database & Graphics Specialist

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The Piero Project

Teaching Art History with Interactive Three-Dimensional Computer Graphics

The Department of Art and Archaeology
The Interactive Computer Graphics Laboratory, CIT
Princeton University
1993

Teaching Art History with Interactive Three-Dimensional Computer Graphics

Using the computer screen to show art objects in a spatial environment that retains the three-dimensional context and relative scale, a research project at Princeton University has produced interactive computer graphics software for use on-line in the classroom. With this program, the spectator can navigate through scanned, full-color images and other information, verbal and visual, thereby gaining access to visual information that is closer to perceptions of reality than those offered by slides and photographs.

The Piero Project

Piero della Francesca's Legend of the True Cross, painted between 1452 and 1466, in the church of San Francesco in Arezzo, Italy, has been used in preparing an experimental pilot project. All the images of the fresco cycle have been scanned from 8 x 10 color transparencies or 2"x2" color slides, and texture mapped into the computer at a level of resolution that functions for close study, distant viewing, and above all, during real-time movement.

Interactive movement is accomplished with the mouse or the space-ball, as well as in chained navigational paths in preconceived order. As a result, this monumental work of art is now visible as a totality; it can be studied, observed, and analyzed in a more complete manner than ever before.

Tools

The Piero Project custom software runs on Silicon Graphics IRIS Workstation with texture mapping capability. The program and data for the Arezzo Cycle occupy approximately 220 Megabytes of disk space and use 48 megabytes of Ram memory. The Mouse is used to produce two-dimensional movement over the surface of the space; the Space Ball is used to drive movement through three-dimensional space. The software consists of a series of extensions to the "Iris Inventor" 3D toolkit and is written in C++. The simulation of three-dimensional architecture was created using AutoCadd. Slides and photographs were scanned with the Nikon LS-351 AF slide scanner and Howtek Scanmaster 300 dpi Flatbed scanner. A database of digitized visual material provides images for comparisons. Joined to these images, a relational database provides verbal information, identifying the images and placing them in their historical, religious, and social ambient.

Classroom Use

This collection of material will be used in an experimental seminar, to be offered to Princeton University art history students (undergraduate and graduate). It will combine discussion of the career of Piero della Francesca (c.1413-1492) and instruction in the use of the interactive computer graphics technology (scanning, digitization, real-time movement, visual and verbal database materials). The seminar will be team-taught by Prof. Marilyn Aronberg Lavin (art historian) and Kirk D. Alexander (manager, Interactive Computer Graphics Laboratory.) They will be joined by members of the faculty of Princeton and other nearby institutions. The substance of study will combine materials of a normal academic course with the format of the new electronic facilities.

APPENDIX 2: VIDEO

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APPENDIX 3: COURSE TITLE, DESCRIPTION, SYLLABUS: PIERO DELLA FRANCESCA ON-LINE:

Sources, Content, Impact: Art historic study using electronic imaging. 400 level (open to Gradvates)

Professor: Marilyn Aronberg Lavin; Graphics Specialist Kirk D. Alexander

Course description (to appear Undergraduate Announcement and "Course Offerings")

> Study of painted works of Piero della Francesca (1413?-1492), exploring the use of new techniques of electronic imaging (scanning, digitalization, real-time movement, visual/verbal database materials). Students will learn to use new hardware (Silicon Graphic VGX workstation; Sony scanner) and software (created in the ICGL for this purpose) to prepare and present the required term paper.

Course Format: seminar (lectures/lab)

Sample Reading List:

> Eugenio Battisti, Piero della Francesca, Milan, 1971, 2 v (2d ed. 1992)
> Carlo Bertelli, Piero della Francesca, London, 1992
> Ronald Lightbown, Piero della Francesca, Oxford, 1992
> M.A. Lavin, Piero della Francesca, New York, 1992
> Introduction to Computing at Princeton, CIT

Typical Weekly Assignment: Reading monographs and specialized articles on works of art under discussion. Researching and scanning images. Instruction in operation of software, mouse and space ball.

Course Requirements: Ability to operate standard computers

Prerequisites: Survey course in Western Art; Renaissance Survey

Grading: Pass/Fail option is not available; Audit is not available.

Other Information: Specialists in fields other than Renaissance painting, from the Princeton faculty and art history faculties of other nearby institutions will join the seminar.

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SYLLABUS: Piero della Francesca On Line

1. Introduction: Men and Machines:
General background on Piero della Francesca; orientation in the Interactive Computer Graphics Laboratory; operation of the Silicon Graphics VGX IRIS Workstation

2. Early Career (1432-1450): Lecture: Sansepolcro, Florence, Ferrara; instruction in the use of verbal databases and operation of the Flatbed and Slide Scanners.

3. Rimini; other youthful works; beginning of Arezzo: Lecture; operation of Custom Software Real-time Motion

4. Arezzo cycle (continued)

5. Arezzo cycle; Rome (continued)

6. Arezzo cycle; Magdalene (continued)

7. Flagellation: Lecture and Computer analysis (measuring, three-dimensional geometric diagrams and exploration of light sources

8. Baptism and Madonna del Parto: Lecture and plain geometry analysis and exploration; spatial analysis

9. Altarpieces: Augustine; Antonine: Lecture and computer reconstruction

10. Portraits: Lecture and computer analysis of placement, use of death masks; copies

11. Resurrection and Brera Madonna: Lecture and computer analysis of perspective and mathematical spatial construction

12. Latest works (Adoration; Senigallia Madonna): Lecture and computer reconstruction; analysis of irrational space

13. Student papers (assigned early in semester on research topics involving collection and scanning of images (comparative material); creation of databases; and demonstrations on the workstation to illustrate intellectual findings.

14. Student papers

15. Student papers

(See Appendix 6, Visual Products)

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APPENDIX 4: LIST OF FACULTY VISITORS TO ART 430

Prof. John Pinto February 1, March 1
Associate Chair
Department of Art and Archaeology
Princeton University

Prof. Archer St. Clair Harvey March 29
Department of Art History
Voorhees Hall
Rutgers University
New Brunswick, NJ 08903

Prof. Sarah McHam February 22
Department of Art History
Voorhees Hall
Rutgers University
New Brunswick, NJ 08903

Prof. Rona Goffen February 15
Chair
Department of Art History
Voorhees Hall
Rutgers University
New Brunswick, NJ 08903

Ben Kessler February 22
Director of Slides and Photographs
Department of Art And Archaeology
Princeton University

Prof. Marcia Hall February 22
Department of Art History
Tyler School of Art
Temple University
Beach and Penrose
Philadelphia, PA 19126

Prof. Florenz Deuchler April 5
Director
Istituto Svizzero
Rome, Italy

Prof. Mary Vidal March 29
Department of Art and Archaeology
Princeton University

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Dr. Norman Muller April 5
Conservator
The Art Museum
Princeton University

Dr. Besty Rosasco April 5
Curator of Renaissance Art
The Art Museum
Princeton University

Prof. Richard Brilliant April 5
Department of Art History and Archaeology
Columbia University
Schermerhorn Hall
New York, NY 10027

Prof. Patricia Fortini Brown April 5
Dept. of Art and Archaeology
Princeton University
and 12 members of Freshman Seminar on Portraiture

Prof. Richard Stapleford April 12
Department of Art
Hunter College
68th and Park
New York, NY

Prof. Dale Kinney, Chair, Art History
Dr. Suzy Spain, Assist. to President April 20
Bryn Mawr College
Bryn Mawr, PA

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APPENDIX 5: EVALUATIONS

A. Students comments (June 1994):

"The 3D Program is by far the most important component and the most important tool to advance the study of art history". (Graduate student)

"The course presents an in depth view of the work of Piero and enables analysis of paintings and cycles using the most advanced technology." (Graduate student)

"The range of information in the database is excellent, and the instructors were excellent in responding to student suggestions". (Senior)

"At first I was so nervous with the machine, I felt ill. I didn't understand what a database was or why we had to use it. But then I began to see that I could find more information than I knew existed. It became a part of the problem I was given to solve. I learned about how real problems are solved in a real way, even though they happened 500 years ago". (Senior)

"By reconstructing a fresco cycle I got to know the paintings in a new way. At first I wondered why I had to think about where things went. Putting parts into the machine taught me what the artist thought about when he worked, and that he had very smart ideas." (Freshman)

B. Visiting Professor Comments:

"...an astonishing display of what the future holds..." .

"Your program literally allows an intimate involvement with a work of art that is a revelation at the classroom level and potentially invaluable for more advanced research. As a teaching tool, it allowed...the three dimensional reconstruction of spaces that have confounded students and experts in the past. It delivered diagrams, reconstruction and other essential information quickly and invited manipulation of data on the spot."

"..I will lie awake for a week thinking of applications for this exciting technology that has the capacity to revolutionize the types of questions we can study and ...one person can ask of the material in a lifetime. It is amazing...that you have trained one class of student already to think in these new ways."

Comment from a participant at the American Academy in Rome:

"Your presentation... of the computer project that you have developed at Princeton was so exciting and so compelling that I am trying to propose a trip to Princeton to have you present the materials in a workshop for both the computer experts at this University and the professor from the Art History Department. Since the ramifications

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for the use of your imaginative project are so vast, the possibilities for its use are endless. I myself in classics can see immediate application for it in teaching literature and history, as well as art history.

You really excited the whole group to whom you presented your videotape at the AAR. None of us had every seen a computer program that used twentieth century technology to such imaginative advantage in recreating the experience of being a part of the work of the artist. The entire registers of the panels were made so intimate a part of the viewer's experience that it was really more complete than a trip to view the real materials. One could never climb up high enough to see the upper panels so clearly. Your ability to relate them in form and content and to cause the entire construction to move in space used the capabilities of the computer to its full advantage. And your subsequent assignment of the project to inspire your students to design their own further exploration takes the project a step beyond your own immediate goal...."

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APPENDIX 6: VISUAL PRODUCTS (from ART 430)

Three-dimensional models:

Figure 1. Chancel, San Francesco in Arezzo: Basic Architectural Framework
Figure 2. Image of the Arezzo Cycle as reconstructed for the *ECIT* software
Figure 3. The Piero Project: Multiple Viewing Windows
Figure 4. Spotlight
Figure 5. Detail Boxes
Figure 6. Arezzo Cycle with overlaid Geometric Lines
Figure 7a. Piero Lecture Slide Lists
Figure 7b. Slide List for a Special Lecture on Portraits
Figure 8. Student Work: Brancacci Chapel , Masaccio and Masolino
Figure 9. Student Work: Chancel of Duomo of Prato, Fra Filippo Lippi

Painting Models:

Figure 10. Student Work: St. Anthony Altarpiece, Piero della Francesca
Figure 11. Student Work: Montefeltro Altarpiece, Piero della Francesca
Figure 12. Student Work: St. Mary Magdalene, Piero della Francesca
Figure 13. Chancel of Santa Croce, Agnolo Gaddi , Cycle of the True Cross
Figure 14. Student Work: The Flagellation, Piero della Francesca
Figure 15. Student Work: Tempio Malestiano and Portrait of Malatesta, Piero della Francesca
Figure 16. Diagram, Baptism of Christ, Piero della Francesca

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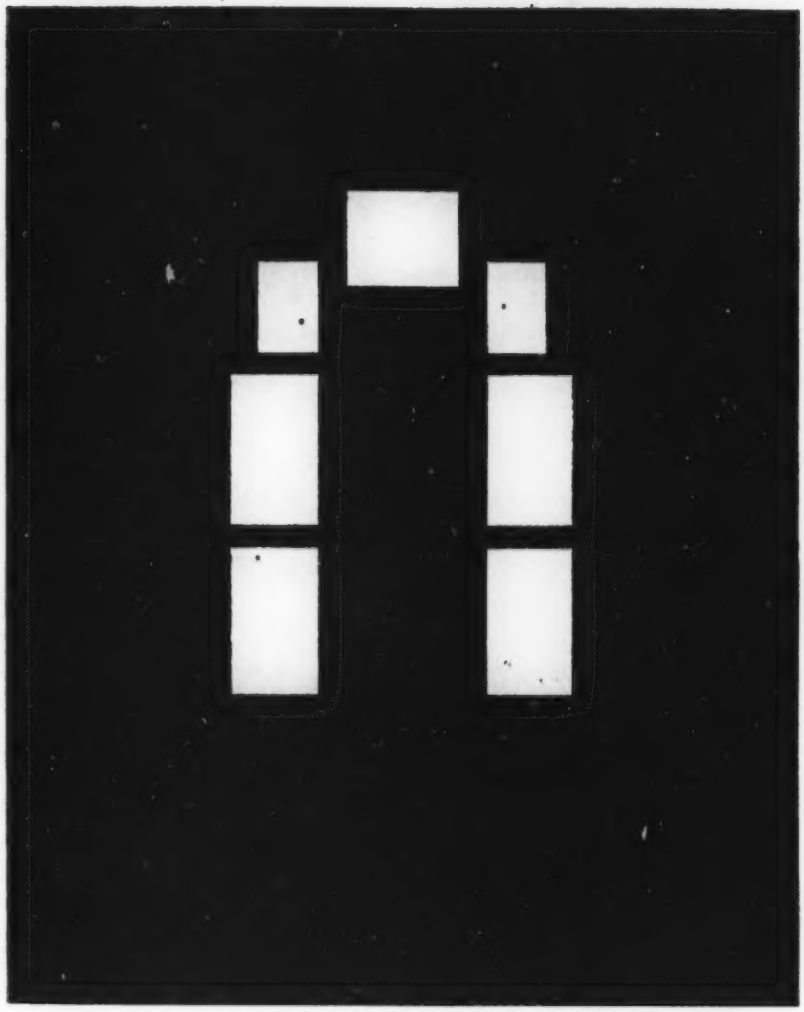

Figure 1: Chancel, San Francesco in Arezzo Basic Architectural Framework

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Figure 2: Image of the Arezzo Cycle as reconstructed for the *ECIT* software

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Figure 3: The Piero Project, an application for teaching art history using interactive 3D computer graphics. This image shows a reconstruction of the Church of San Francisco in Arezzo, Italy. Clicking on the fresco brings up the higher resolution image shown at right. Clicking on a white sphere allows the user to view the scene from that position. White spheres can be connected to create an animated tour of the church.

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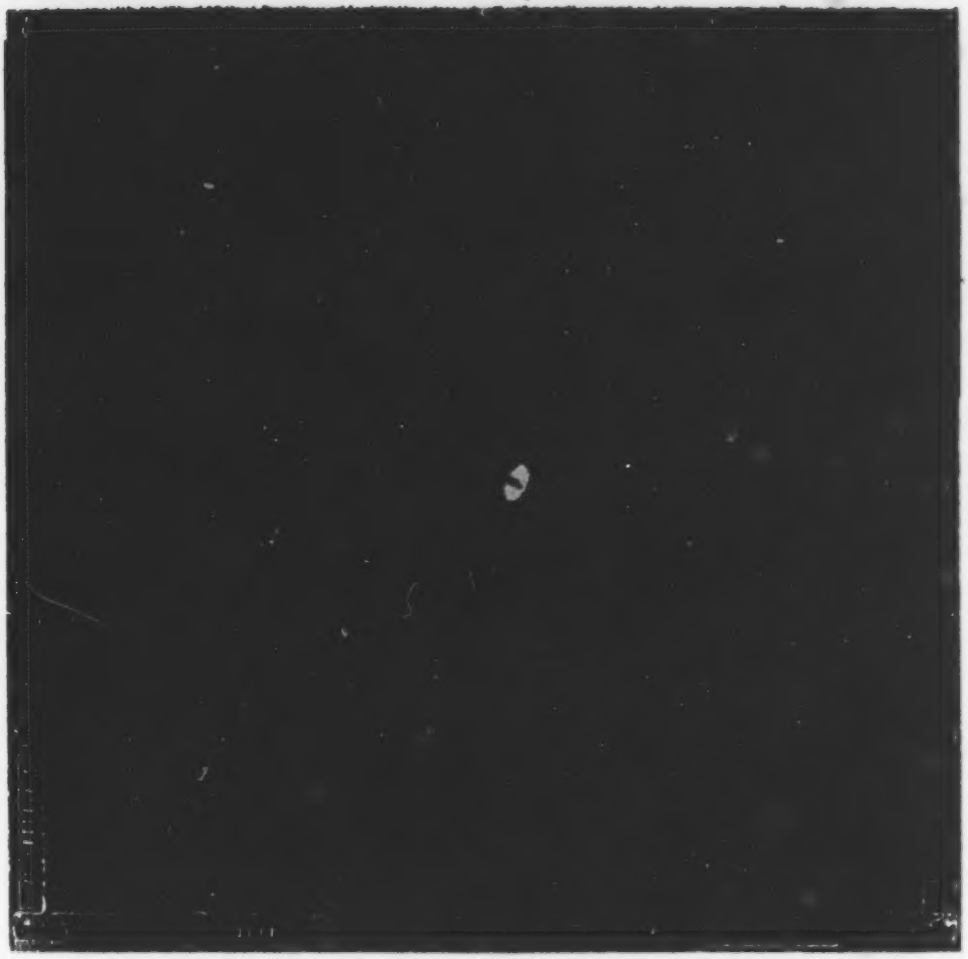

Figure 4: Spotlight

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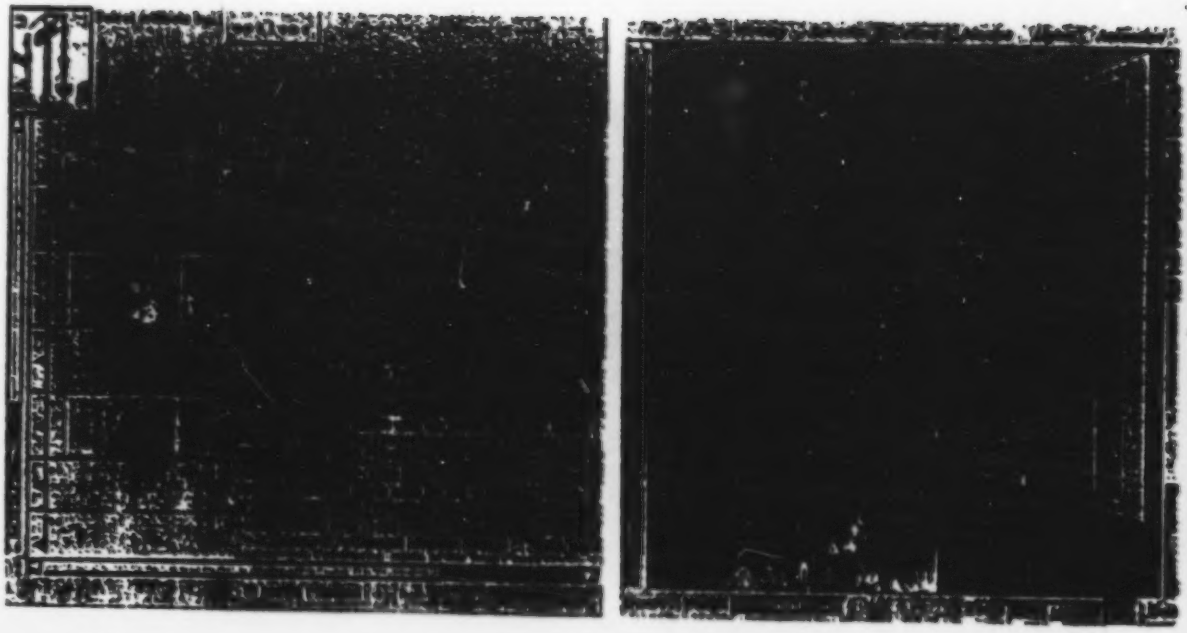

Figure 5: Detail Boxes

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Figure 6: Arezzo Cycle with overlaid Geometric Lines

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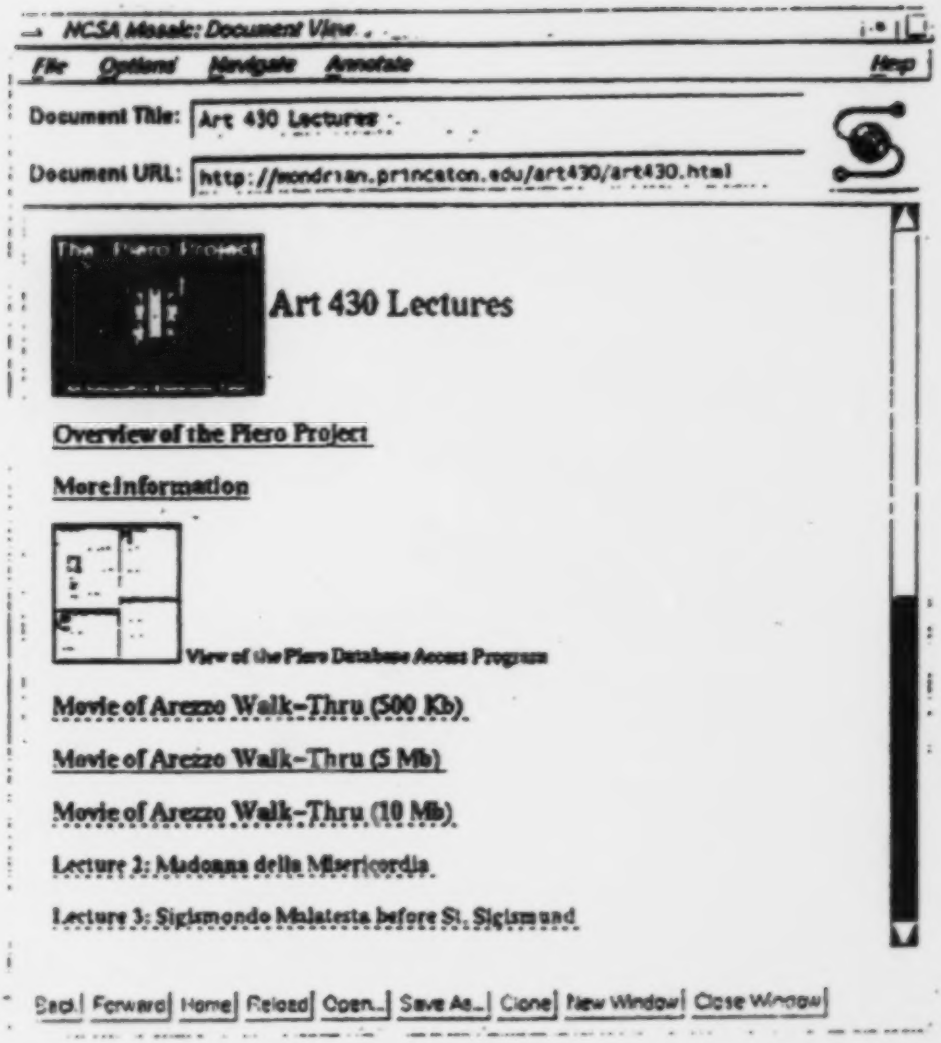
NCSA Mosaic: Document View
File Options Navigate Annotate Help
Document Title: Art 430 Lectures
Document URL: http://mondrian.princeton.edu/art430/art430.html
Art 430 Lectures
Overview of the Piero Project
More Information
View of the Piero Database Access Program
Movie of Arezzo Walk-Thru (500 Kb)
Movie of Arezzo Walk-Thru (5 Mb)
Movie of Arezzo Walk-Thru (10 Mb)
Lecture 2: Madonna della Misericordia
Lecture 3: Sigismondo Malatesta before St. Sigismund
Back Forward Home Reload Open... Save As... Clone New Window Close Window

Figure 7a: Piero Lecture Slide Lists

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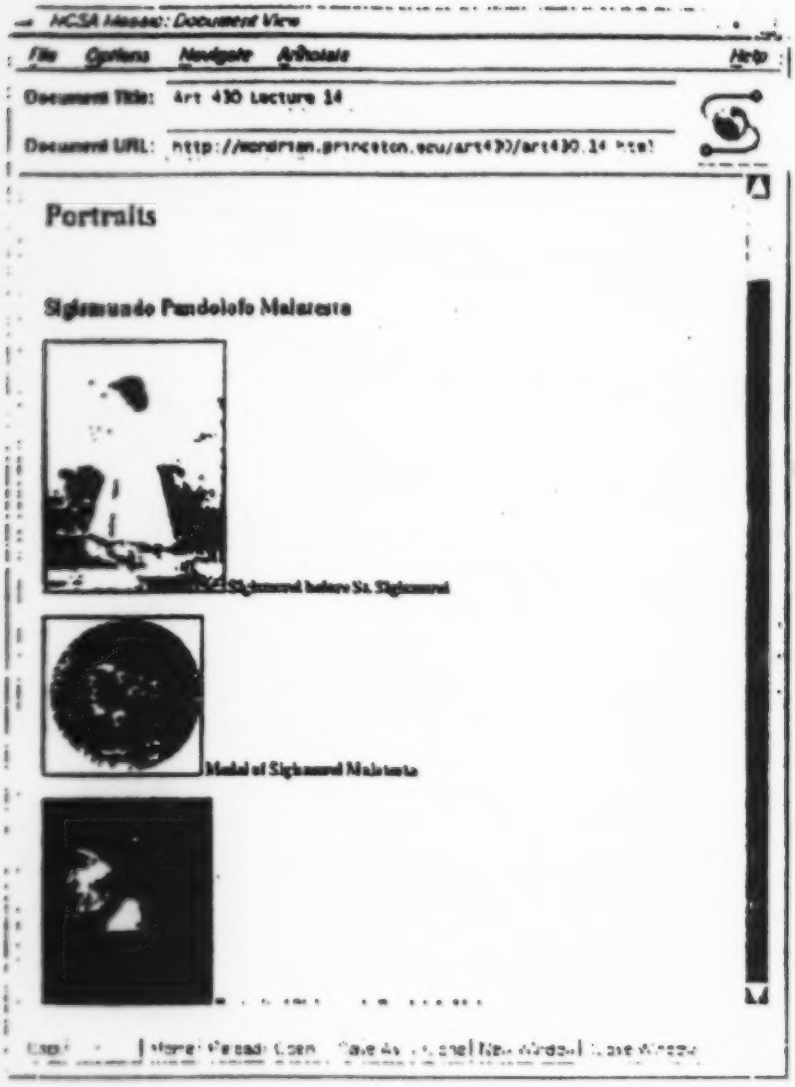

Figure 7b: Slide List for a Special lecture on Portraits

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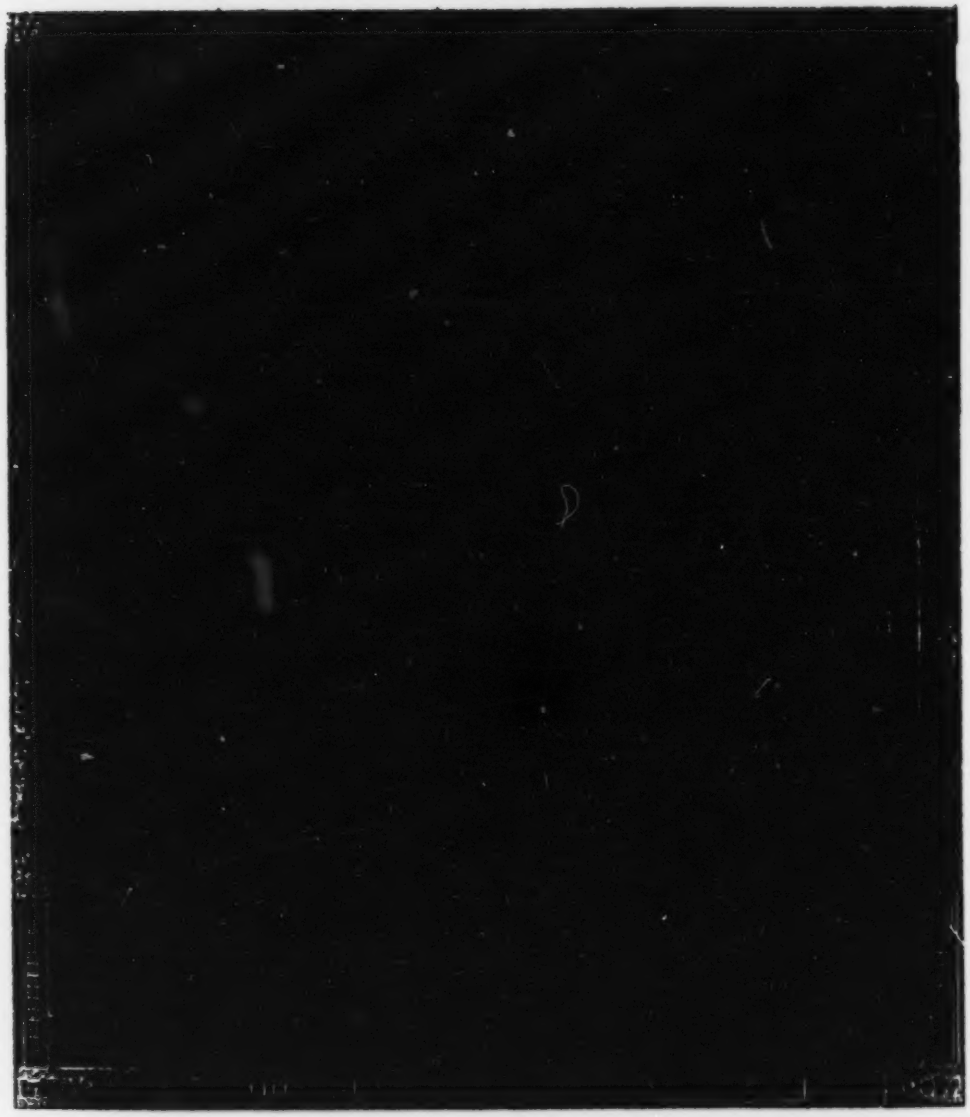

Figure 8: Student Work: Brancacci Chapel , Masaccio and Masolino

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Figure 9: Student Work: Chancel of Duomo of Prato, Fra Filippo Lippi

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Figure 10: Student Work: St. Anthony Altarpiece, Piero della Francesca

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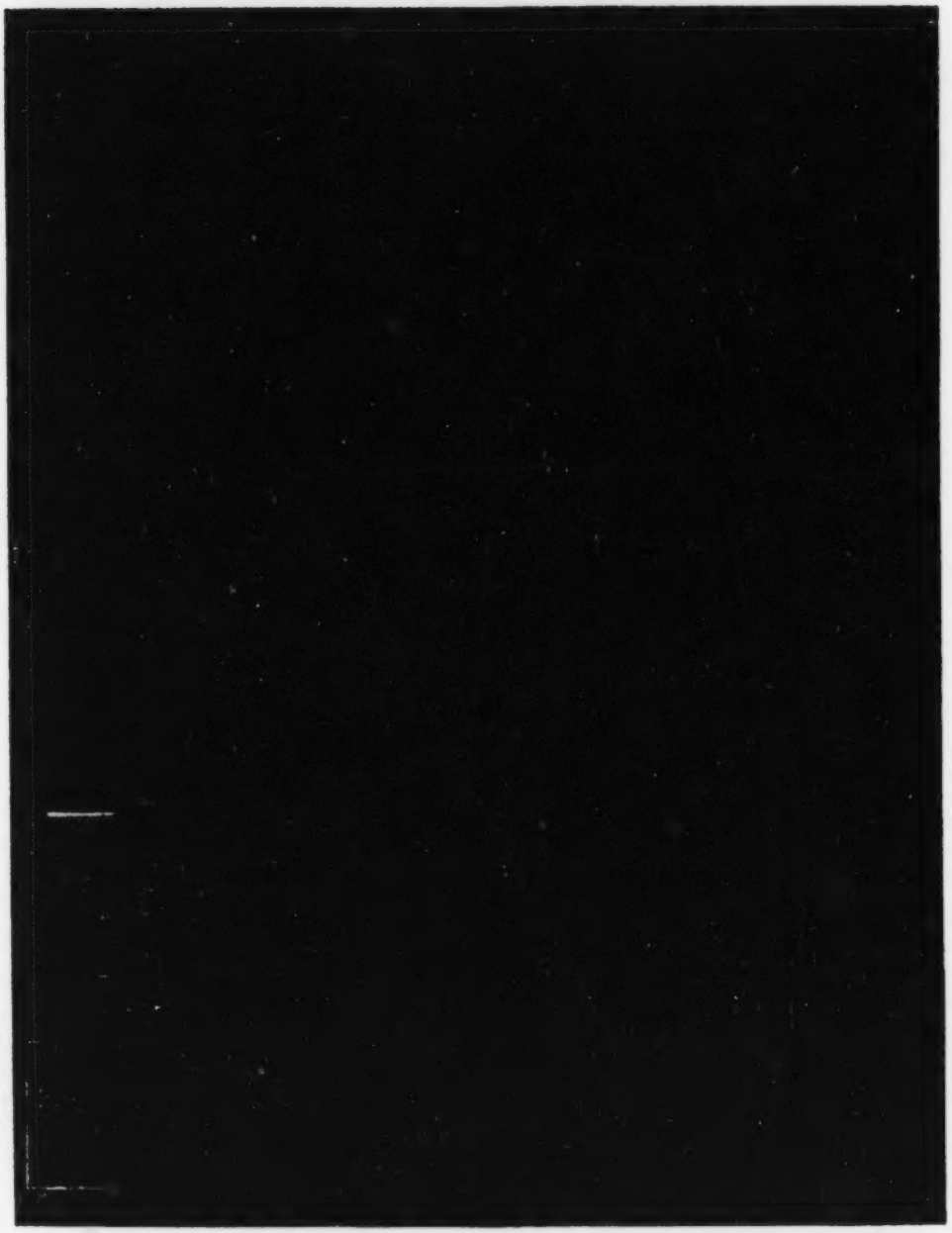

Figure 11: Student Work: Montefeltro Altarpiece, Piero della Francesca

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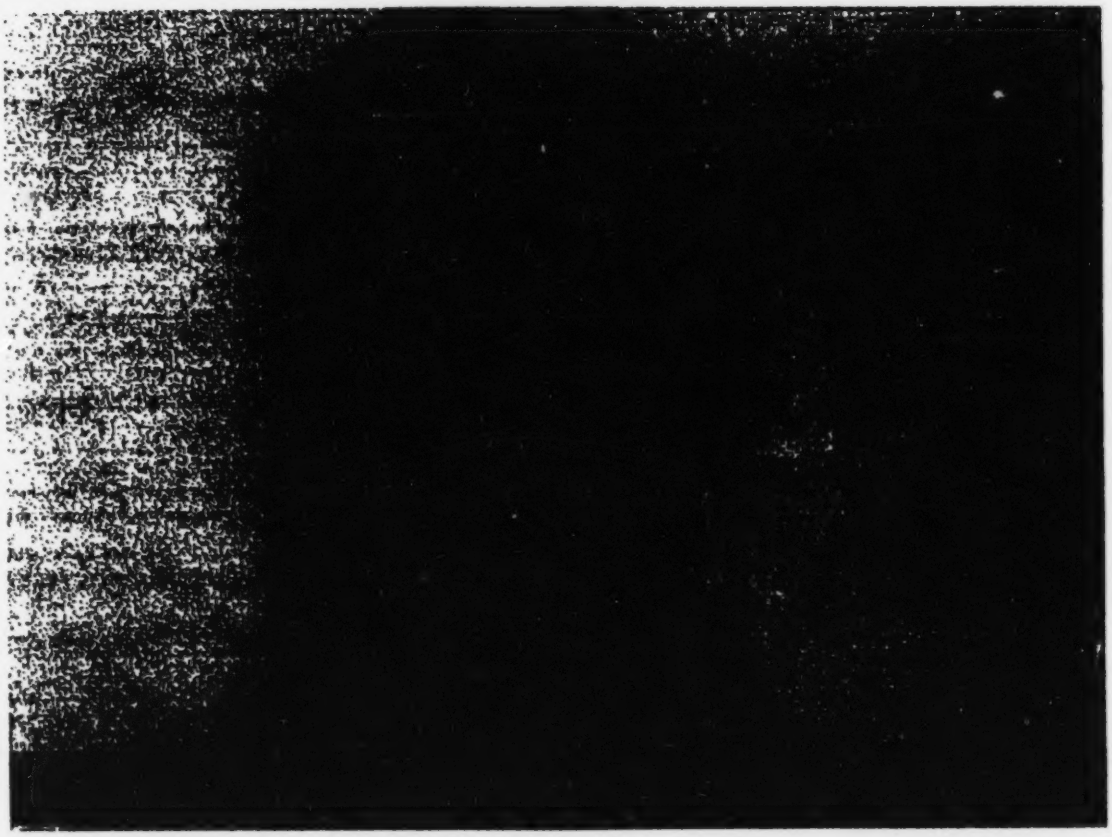

Figure 12: Student Work, St. Mary Magdalene, Piero della Francesca

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Figure 13: Chancel, Santa Croce, Agnolo Gaddi., Cycle of the True Cross

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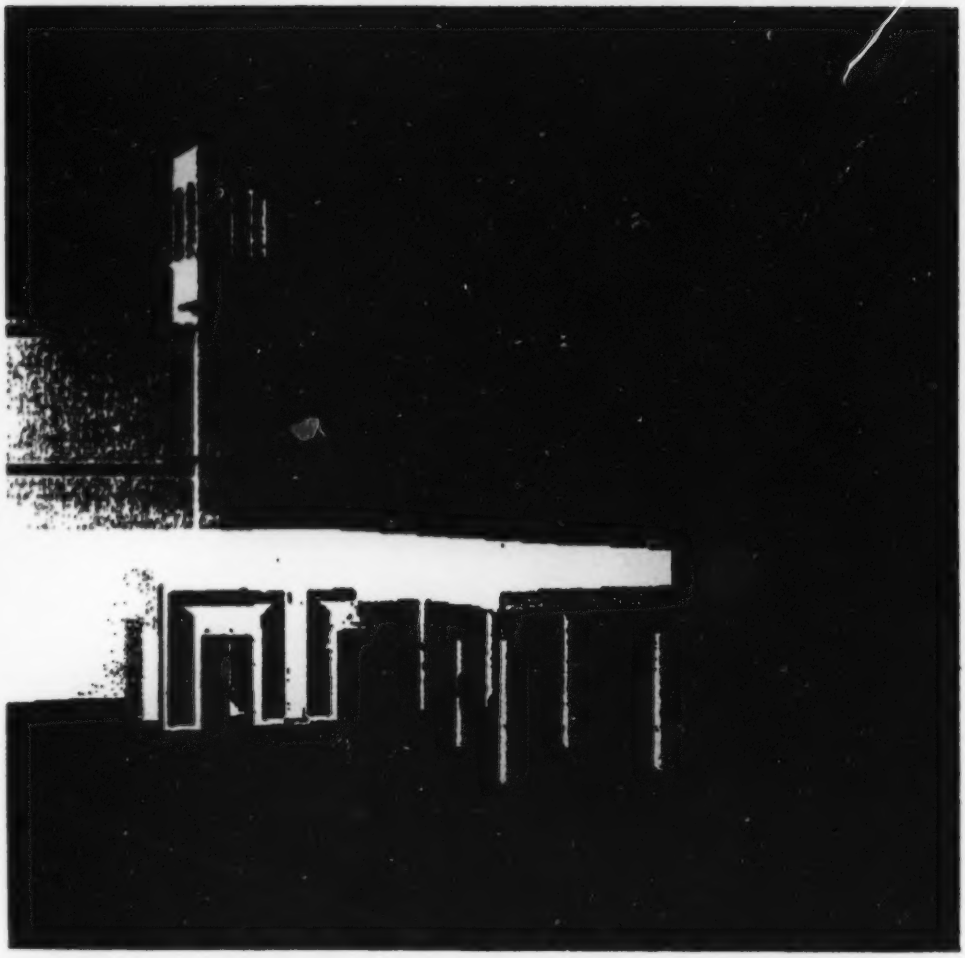

Figure 14: Student Work: The Flagellation, Piero della Francesca

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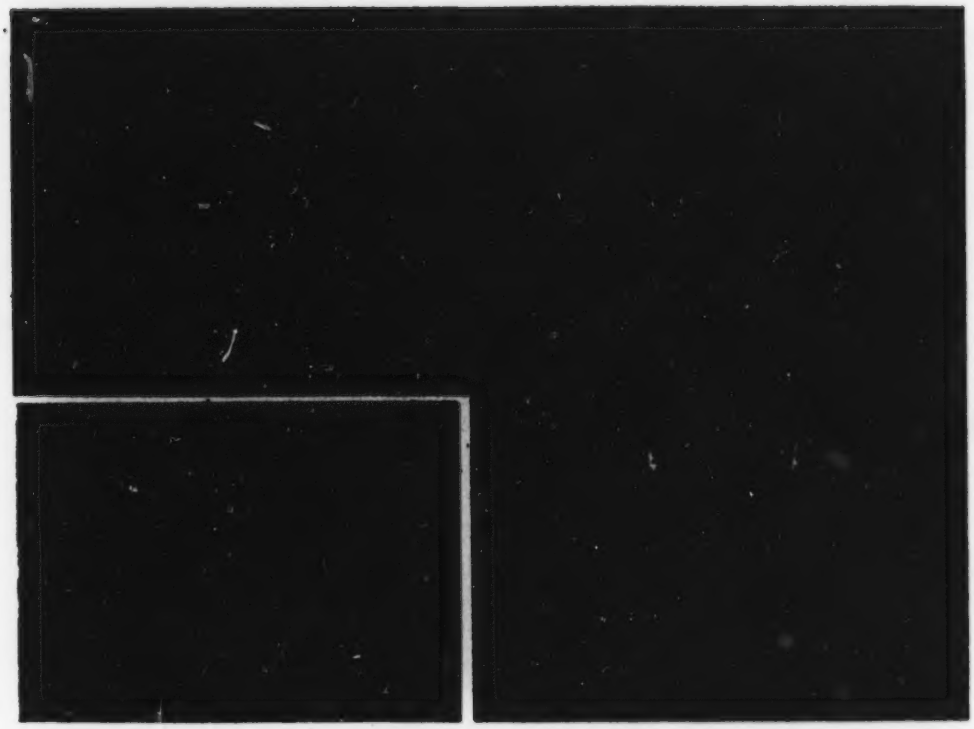

Figure 15: Student Work: Tempio Malestiano and Portrait of Malatesta, Piero della Francesca.

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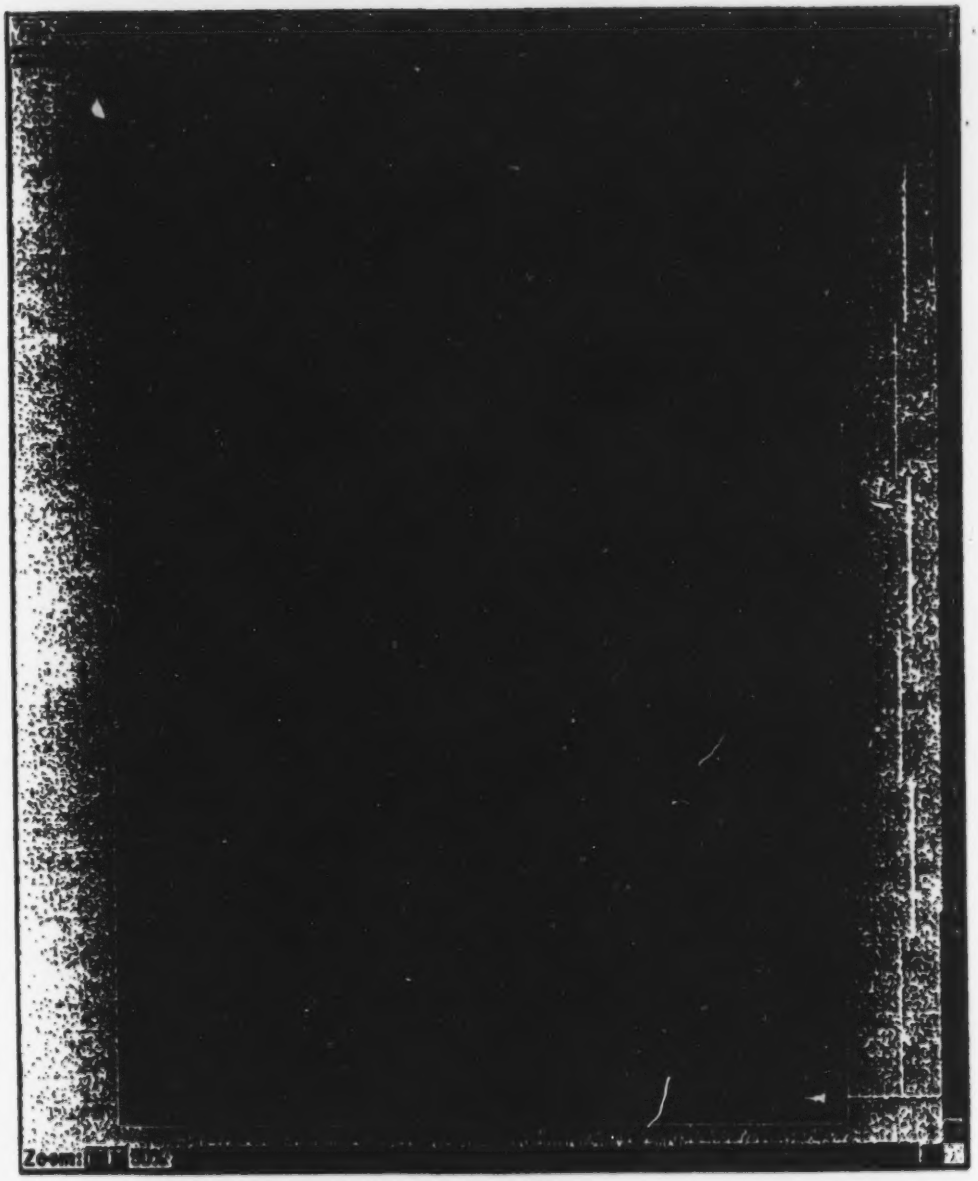

Figure 16: Diagram, Baptism of Christ, Piero della Francesca

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APPENDIX 7: DISSEMINATION:

A. Video Copy Presentations to date:

1. Washington DC. 2/1991. 1st Tape (Video Sketch). Annual Meeting, College Art Association of American; First Meeting of Committee on Electronic Information - MAL
2. Taxco, Mexico. 10/1991. 1st Tape (plus Space Ball Tape addition). Mexican Art History Colloquium - MAL
3. Athens, Greece. 7/1992. 2nd Tape. Chief Architects of the Acropolis, and Epidavrous (2 Sessions) -KDA, KRP
4. Berlin, Germany. 7/1992. Live Demonstration with VGX. International Congress of Art History, CIHA - MAL, KDA, KRP
5. Arezzo, Italy. 1/1992; 3rd Tape, Convegno su Piero della Francesca (International Conference on 500th Anniversary of Piero's Death) - MAL
6. Norfolk, Va. 11/1992. 3rd Tape. Chrysler Museum (Hermitage Association) - MAL
7. Washington, DC. 12/1992. Live Demonstration, SGI Reality Engine. National Gallery of Art, Center for Advanced Study in the Visual Arts. Monarch della Pittura: Piero and his Legacy, Colloquium and public audience - MAL, KDA, KRP
8. Princeton Univ. 12/1993. 3rd Tape. Dept. of Art and Archaeology - MAL, KDA, KRP
9. Princeton Univ. 12/1993. 3rd Tape. Computer Science Graphics Luncheon - KDA, KRP
10. Vinci, Italy. 12/1992. 3rd Tape, Colloquium on Creativity, World Association of Art and Science (WAAS) - MAL
11. New York, NY. 2/1993. 3rd Tape. "Facets of Piero," Conference, Graduate Center, City University of New York - MAL
12. Princeton Univ. 2/1993. 3rd Tape. Alumni Day, Live demo. ICGL - KDA, KRP
13. New York, NY. 3/1993; 3rd Tape, Staff, Metropolitan Museum of Art - KDA, MAL
14. Notre Dame Univ. 3/1993. 3rd Tape. Dept. of Art History - MAL
15. Paris, France. 3/1993. 3rd Tape. Istituto di Cultura Italiano - MAL
16. Santa Monica, CA. 6/1994. 4th Tape. J. Paul Getty Trust, Art History Information Program - KDA, PV
17. Naples, Italy. 6/1994. 4th Tape. Istituto Italiano per gli Studi Filosofici -MAL (for list of attendants, see Appendix 2)
18. Rome, Italy. 7/1994. 3 demonstrations, 4th Tape; American Academy in Rome -MAL

B. Two television appearances (NJNET and BBCV)

C. Piero colloquium at the National Gallery of Art, Washington, DC. 12/92

Attendants at Demonstrations in Italy, 6-7/94

NAPLES: class of 25 graduate students from the University of 25 undergraduate students from Naples, Rome, and Berlin.

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Those with specific interest:
Paola d'Agostino (Pietro Bernini);
Rosa Romano d'Orsi (works with computers),
Paolo Giannattasco (Cesare da Sesto, drawing, red chalk and brown ink, pen)

ROME: 3 separate demonstrations:
All faculty members; **= expressed interest in collaboration:

**Robert Mode, Vanderbilt University, Art History
Elizabeth Bartman, New York City, Classics
**Carol C. Mattusch, George Mason Univ., Chair, Classical Art History
Mary Hollinshead, Univ. of Rhode Island, Kingston, RI, Art Dept.
Caroline House, Smith College, (Northhampton), Art Department
Linda J. Roccos, U.S. Center LIMC, Rutgers University
Margaret Miles, University of Calif., Irvine, Art History
Ruth Weisberg, painter, Chair, Art Department, USC
Deborah Stott, University of Texas, Dallas, TX, Art History
Carmen Bambach-Cappel, Fordam University, NY, Art History
Brian Curran, Princeton University, Art History
**Emily Rose, Princeton University, Medieval History
Miranda Marvin, Wellesley College, Classical Art
**Norma Goldman, classics, College of Lifelong Learning, Wayne State Univ., Detroit, Wis. 48202
Ettore d'Ovidio, University of Rome, Computer Science
**Claudia Cieri-Via, Art History, University of Rome, La Sapienza working on database on Ovid's Metamorphosis, starting from images.

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APPENDIX 8: PRESENT AND FUTURE COLLABORATORS:

1. On Princeton Campus:

a. Dept. of Art and Archaeology:

Trenchmaster (Prof. W. Childs Archaeology)
Architecture (Prof. J. Pinto)
Manuscript Illumination (Prof. J. Marrow)
Art211 Review Slides (American Painting: Prof. Wilmerding)
Prin . ton 250th Anniversary Project

b. Other fields of the Humanities:
Culpeper Projects
Mappamundi (multiple course Mosaic database project, Prof. M. Curschman)
Geology (Prof. B. Phinney)

2. Other Institutions:

a. In the United States:

Bryn Mawr; Rutgers; Columbia
Jerusalem 600-1100 (video from 3D models)
(Institute for Advanced Study, Princeton)
Metropolitan Museum of New York (model for Petrus Christus exhibition and catalog)

b. Europe

University of Rome, "La Sapienza"
Istituto Italiano per gli Studi Filosofici, Naples

3. Research Foundations: J. Paul Getty, Art History Information Program

4. Vendors: Oracle Corporation; Silicon Graphics Inc.

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APPENDIX 9. MAJOR CONTRIBUTORS

Professor William A. Childs, Professor, Department of Art and Archaeology
Director of the project, participating on an advisory level in the principles of scholarly and technical research and in the use and distribution of the tools produced.

Kirk D. Alexander, Manager, Interactive Computer Graphics Laboratory
Alexander was the co-director of the project overseeing technical changes and implementation of the technology in the classroom He also coordinated the dialogue between the art historians and the technical personnel as well as trained the collaborators in the use of the *ECIT* software.

Marilyn Aronberg Lavin, Visiting Lecturer with rank of Professor,
Department of Art and Archaeology
Lavin is course professor in Art 430, "Piero della Francesca On-line." She provided all the research and historical material in *ECIT*. She also trained the collaborators on the issues involved in preparing art historical information for use in the compendium and on the implications of teaching with this new technology.

Peter M. Vince
Vince is a database specialist who designed and implemented the *ECIT* system. He provided technical guidance for the project, assisted the collaborators in the use of the database and made any required programming changes required to accommodate the new users.

Kevin Perry
Perry is the developer of the three-dimensional component of the software. He performed a similar role to Vince but with respect to computer graphics and modeling.

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APPENDIX 10: THREE-DIMENSIONAL SOFTWARE DEVELOPMENT:

The prototype software for the Piero Project (in existence at the time of our original proposal) had a variety of problems: a lack of flexibility in interaction, non-standard data format, and difficulty of extending the program. It was based on the GL graphics programming library from Silicon Graphics Inc. (SGI), a powerful but fairly low-level interface to the graphics hardware. Our task over the term of the grant has been to re-implement the software using a new, more powerful graphics programming tool, the Inventor 3D Graphics Library from SGI. The Inventor package is an object-oriented library written for use with the C++ programming language. The software objects defined by Inventor represent high-level graphical objects, such as cubes, surfaces, and textures, as well as graphical actions, such as rendering and picking. This environment is ideal for coding complicated graphical applications such as the Piero Project software.

Development in the first year of this grant occurred in two phases: first, re-formulation of the basic program using the new Inventor library to obtain functionality at least equivalent to the prototype; and second, extension of the software to add new functionality. In the first phase, we spent much time learning about the Inventor software but we were aided in this by our close ties with the tool kit's authors. The task of programming the basic viewing software was greatly simplified by the new programming tools. Additionally, many basic interaction modes, such as picking and seeking functions, are immediately available with few added programming requirements, so the first-phase re-implementation yielded a much more robust program than the prototype, with significantly less programming effort. We were also required to translate our database of geometric and image data from our original in-house format into the more standard Inventor data file format. The resulting product of this first phase immediately satisfied our requirements as a very useful tool for doing simple exploration of Piero's frescoes in the apse of the church of San Francesco in Arezzo.

We then proceeded to the second phase (new functionality) to support higher-level exploration of the space. To do this, we added a number of new types of conceptual objects to the program. We implemented two methods of interacting with frescoes to obtain extremely high-resolution flat images in a separate window on the computer screen. High resolution facilitates examination of details beyond that offered by the 3-dimensional (3D) spatial context provided by the phase I software (Fig 3). Another added feature is the ability to create "diagrammatic geometry" by using the mouse to sketch lines directly on the underlying geometry (i.e. simulated walls) or by drawing lines through space, to distant features (Fig 6). Such diagramming is useful for making notes about the geometric constructions in the works of art, and for highlighting interrelationships between frescoes. We also added a class of objects that serve as position "markers". These are small objects that float in the 3D space, marking a position and a view direction. These can be placed in the space by a teacher for example, and then accessed by students, who use them to navigate through the space. By clicking the mouse button on a marker, the student can "fly" to the given position and orientation in the space, to examine a view deemed particularly

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interesting. In addition, a group of markers may be strung together into a complete automated tour which, when activated, fly the user through the space along the path defined by the list of markers (Fig 3). We have used this ability to pre-program a guided tour of the chapel that views the frescoes of the cycle in their proper narrative order.

We also found it necessary to implement an automated level-of-detail switching mechanism. This device allowed us to maintain real-time motion, by displaying a somewhat blurry, "low-resolution" view during interactions with the mouse, while preserving the ability to see higher resolution views while not in motion. This phenomenon matches human perceptual modes, in the sense that one tends to pause to examine visual details, rather than attempting to focus on details while walking or turning one's head. Initially this methodology was necessary given the technical limitations of our early computer hardware. More recent hardware (like the Reality Engine) obviate the need for this technique. However, it is still useful on lower cost workstation and makes it possible to run this software on such equipment.

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APPENDIX 11: DATABASE SOFTWARE INTERFACE

Technical Description

The Piero project comprises two distinct activities: firstly the design and construction of a relational database, secondly the fashioning of an interactive interface to that data base. This interface, described here, is just one of many possible such dialogs with a cultural data base, and is offered as a model to illuminate the possibilities of mapping user interface elements onto data base structures.
An outline of the interface program's modules follows with a diagram showing an example of the program logic supporting users' interactions with the database.

The Database

The database is constructed using Oracle Corporation's relational database management system.
Described here is the design of the database; what entities are represented and how they are related to each other. Database schema diagrammatically illustrate the structure. In addition to the basic relational engine, we used Oracle's SQL*Net to provide the vehicle for implementing the client/server functions. A combination of the batch loader, SQL*Loader, SQL*Plus and custom programs were used to populate/update the database.

The Interface:

The interface application is described in terms of its functional appearance, how it looks and responds to the user. The interface, the Piero application, to the data base is constructed from these elementary tool kits and languages:

- All programs were written in C, and are being rewritten in C++.
- X Windows(X11R4)/Xt Intrinsics/Motif provide the graphical user interface tools.
  The iconic images embedded in the application are X pixmaps
  generated from gif files using a logic based on a gif reader from SGI.
- Oracle database queries are in the form of programmatically generated SQL
  statements passed to the database engine using Oracle's embedded SQL, Pro*C API.
- In the role of a client, the application uses Oracle's network product,
  SQL*Net, to communicate with the data base on a remote server platform.

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Database Design and Implementation

As the analyst confronts the art historian's work, the initial goal is to identify the domains of knowledge therein comprising the significant aspects as far as the construction of a database.

(1) The primary entity is the art work, generalized as the artifact.
We use "artifact" in the most general sense, as some product of human activity, and so can include geographic entities such as cities, nations, bibliographic references as well as altarpieces, paintings and chapels. This all–inclusiveness is actually useful in locating items geographically – see meronymy below.

(2) The second entity is the set of agents; people, as individuals or groups, who are instrumental in some direct or indirect way in the production of the artefact. Artists, sculptors, patrons, students and teachers reside in this concept along with mythological or historical figures comprising the subject matter of the works.

(3) As the works are subjected to the historian's analysis, details are isolated that have some particular visual significance. Termed the iconographic domain, these are collected under the rubric "content."

(4) The broader cultural and historical references, the iconology of the study, within the database are enumerated within the domain is termed the "context" of the study.

These domains comprise the four entities, the tables in database language.
Again, it should be stressed that the goal here is not to produce an exhaustive inventory of artifacts, nor was the intent to capture all data about any work or person.

Having identified the four significant entities in the study, the next task is to identify those attributes of the entities that are determined significant.
Below, we list with each database entity ,the set of attributes we have judged useful in the application.

(1) ARTIFACT:
Thus the attribute list that is used to describe an artifact is limited to:

- type.
  All artefacts are typed according to a home brewed taxonomy of the order, "painting", "sculpture", "manuscript", etc.
- title.
  The name by which the artifact is commonly known.
- date(s) of construction.
  A simple dating scheme that only attempts to capture the beginning and end dates of the main construction.
- creator.
  The identification of the primary creative agent, if known.

(2) PEOPLE:
Agents are simply described through:

- name.
  The notion of "first" and "last" names is historically recent, some attempt has been made to adhere to it where feasible.
- dates.
  Birth and death dates where known.

(3) CONTENT:
Content entries are denoted by:

- type.
  All content entries are typed – 'iconographic element,' 'design element' for instance.
- description.
  A text field descriptor, e.g. "the peplos (classical costume)" as an example of 'iconographic element"

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(4) CONTEXT:
Context entries are denoted by:

- type.
  All context entries are typed – 'liturgical feast,' 'historical event' for instance.
- description.
  A text field descriptor, e.g. "the feast of the Assumption" as an example of a .'liturgical feast."

Links
The fifth domain, the link table, supplies the mechanism whereby many–to–many relationships are made possible.
Its structure binds two items in any of the above four tables in a generic source/target relationship. Any item in any table may have as many links as desired; an artist, for instance, may have been employed by many partons, a patron may have been the employer of many artists.
(5) LINK:
Link attributes are:

- source table identifier.
  "artifact", "people", "content" or "context."
- source item identifier.
  unique row identifier of item in source table.
- target table identifier.
  "artifact", "people", "content" or "context."
- target item identifier.
  unique row identifier of item in target table.
- link type.
  within the source/target binding, the linktype specifies the nature of the relationship between source and target items, e.g. an artifact may be related to another as a "diagram of" that artifact; a person related to another through the "patron/employee" link.

Of ancillary importance are the code tables which provide the substance of the "authority files," taxonomies which place the subject entity in some category space.
(6) CODE:
Attributes are:

- entity name.
  The table name to which the code applies, e.g. "artifact".
- column name.
  That entity's attribute subject to codification, e.g. "artifact type."
- code
  "Altarpiece" for example.

The "link type" attribute of the LINK table is codified through the LINKCODE table.
(7) LINKCODE:
Tying source and target items together, its attributes are:

- source table
  An identification of the source table.
- target table
  An identification of the target table.
- linktype
  A member of the source/target table relation set.

Thus all relationships between table items are subject to this encoding.

As an artifact may, or may not, have an associated image, a separate IMAGE table was formed.
(8) IMAGE:
Attributes are:

- filename
  Images are pointed to, rather than contained by the database.
- dimensions.

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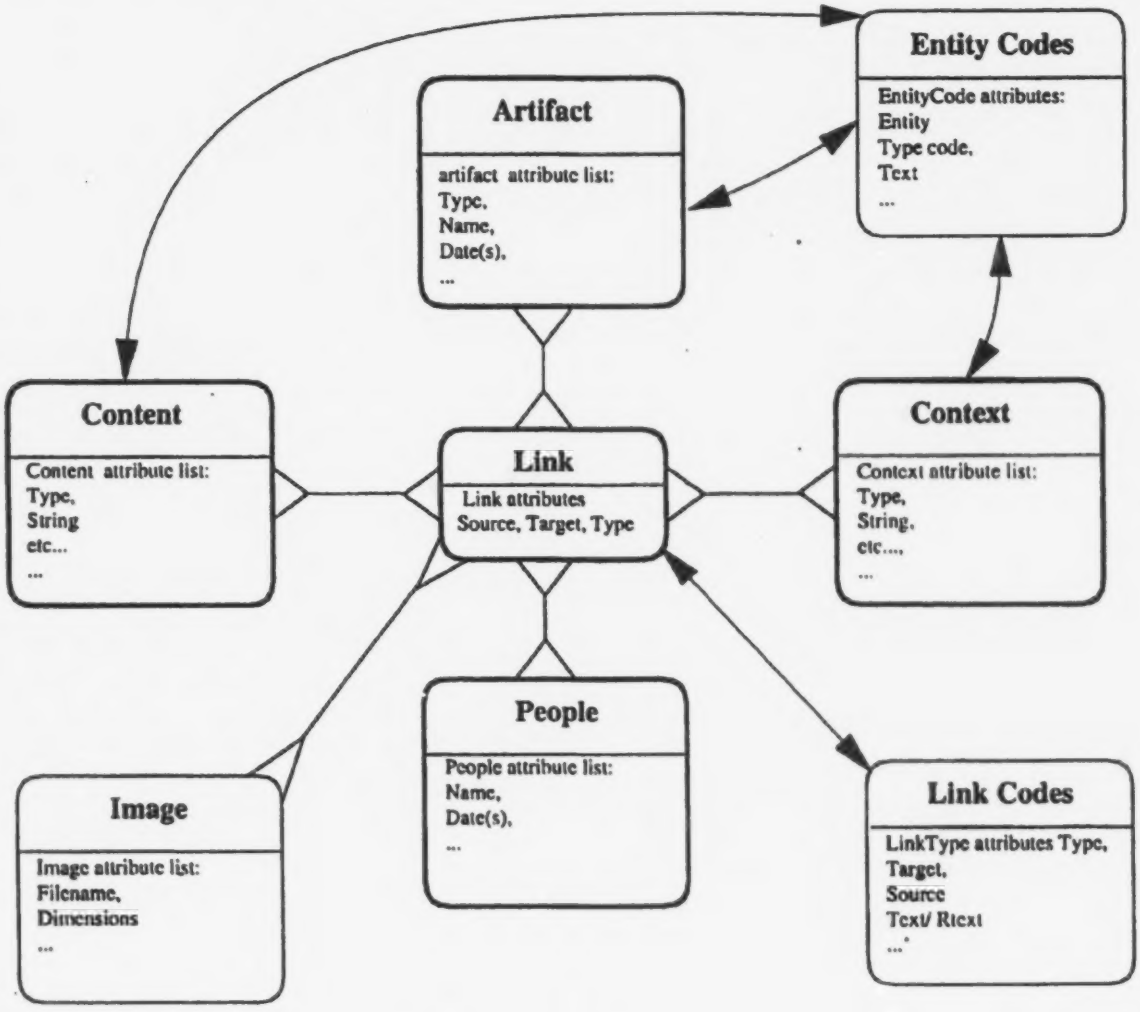
The Piero database Schema

The following pages offer simplified diagrammatic versions of the database.
First, an overall view of the database.
Second, an illustration of how the LINKCODE table plays a part in the linking process
And third, a general encoding example



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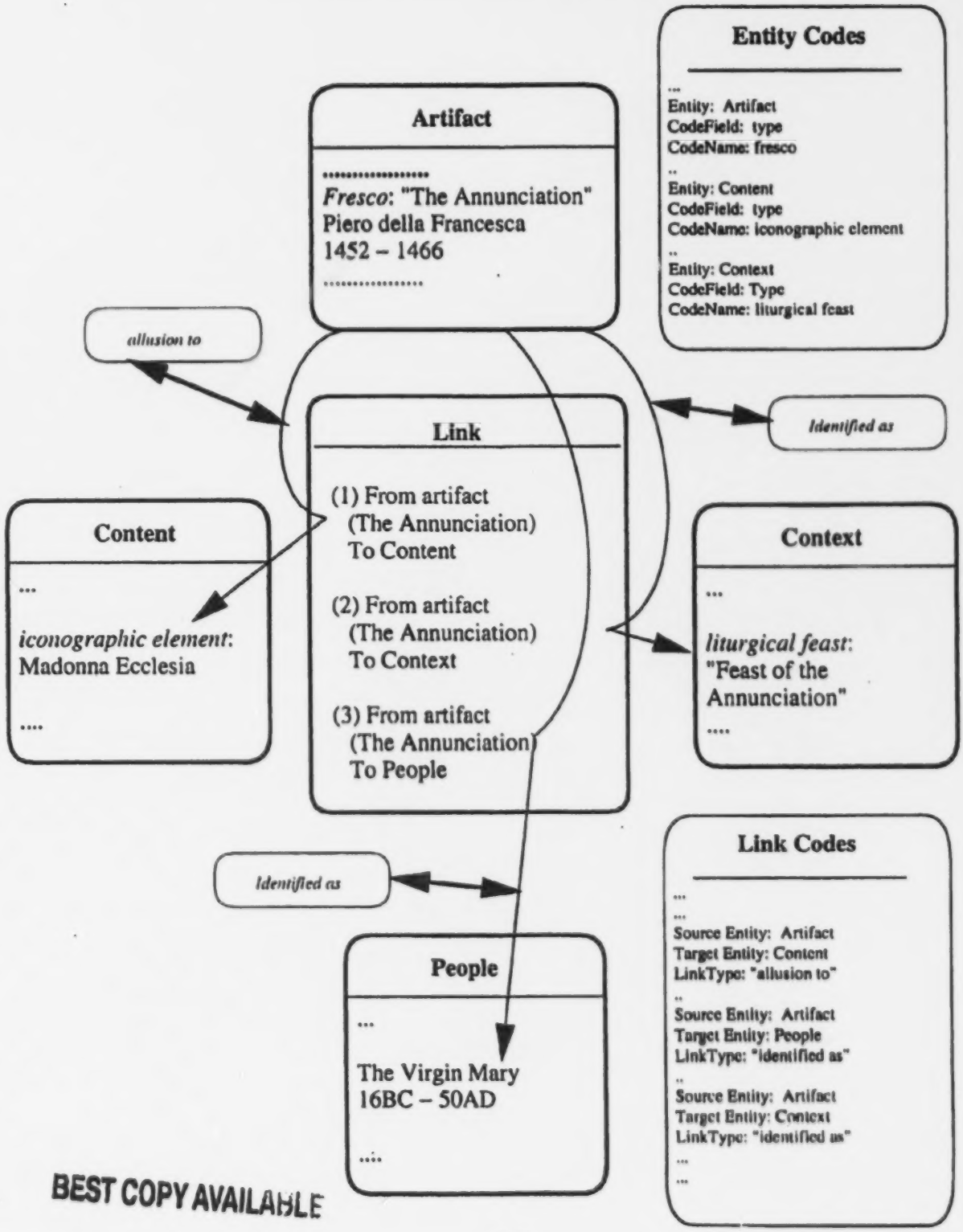
The Piero data base: Link Dialogue Sample



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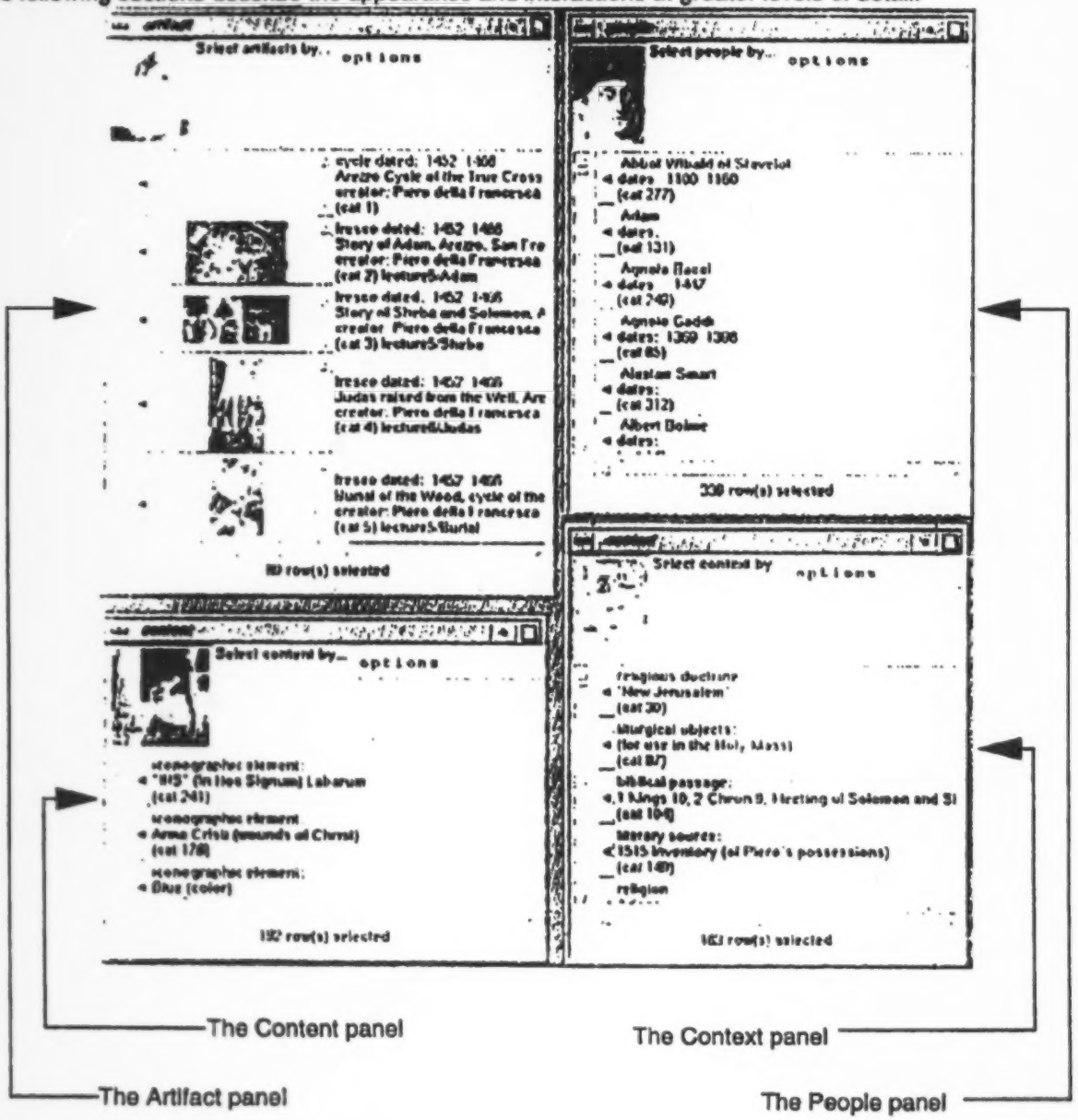
The Application

This is the initial shape of the application. The user is presented with the immediacy of simultaneous streams of information from the four primary domains in the database.

The four panels represent the Artifact, the People, Content and Context tables. Each panel window is independently manipulatable. Selections and interactions in any window do not necessarily alter the appearance or contents in any other window. The point of the linking process, described below, does provide for inter-window communication.
Throughout the application, various pop-up dialog boxes will appear, be acted on and disappear. This auxiliary functionality is to support various selection options.

The following sections describe the appearance and interactions at greater levels of detail.



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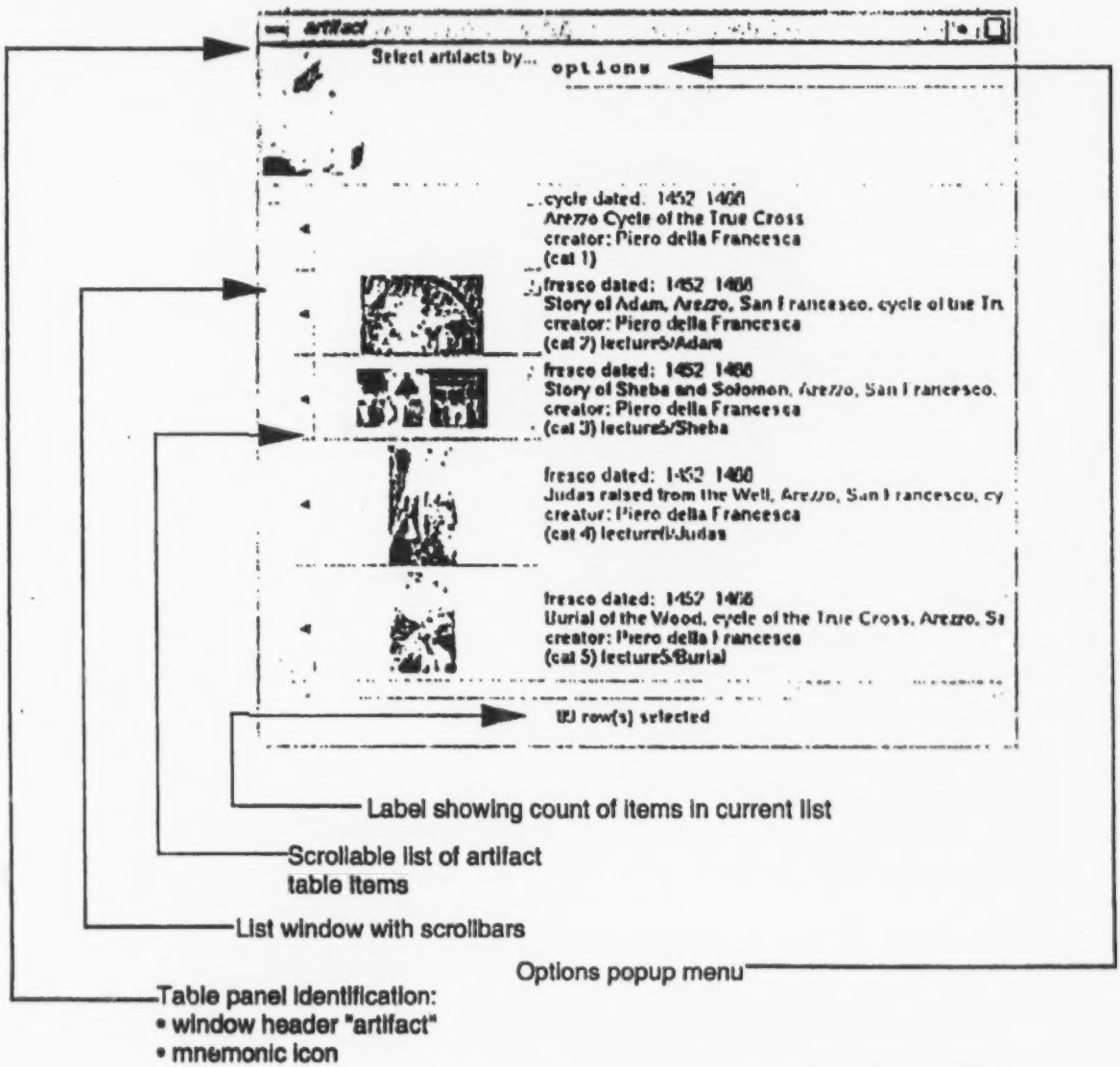
The Table Panel

The table panel has these visual elements:
- table identification by icon and window header,
- an "options" menu to allow list specification,
- a scrollable list window,
- a list of items all or some of which is viewable through the list window,
- a label telling the size of the currently selected list.

The table panel displays a list of items, each of which describes a member of the related database table – a particular painting, person, iconographic item, contextual/historical ideation. Other than its initial state, the contents of a list is the result of a user's interactive selection.
The list itself is presented through a list window which allows its viewport to be moved through the vertical and horizontal scrollbars.

The "options" menu allows initiation of list selection dialogs (see below).


artifact
Select artifacts by...
options
cycle dated: 1452 1466
Arezzo Cycle of the True Cross
creator: Piero della Francesca
(cat 1)
fresco dated: 1452 1466
Story of Adam, Arezzo, San Francesco, cycle of the Tr
creator: Piero della Francesca
(cat 7) lecture5/Adam
fresco dated: 1452 1466
Story of Sheba and Solomon, Arezzo, San Francesco,
creator: Piero della Francesca
(cat 3) lecture5/Sheba
fresco dated: 1452 1466
Judas raised from the Well, Arezzo, San Francesco, cy
creator: Piero della Francesca
(cat 4) lecture5/Judas
fresco dated: 1452 1466
Burial of the Wood, cycle of the True Cross, Arezzo, Sa
creator: Piero della Francesca
(cat 5) lecture5/Burial
10 row(s) selected
Label showing count of items in current list
Scrollable list of artifact table items
List window with scrollbars
Options popup menu
Table panel identification:
• window header "artifact"
• mnemonic icon

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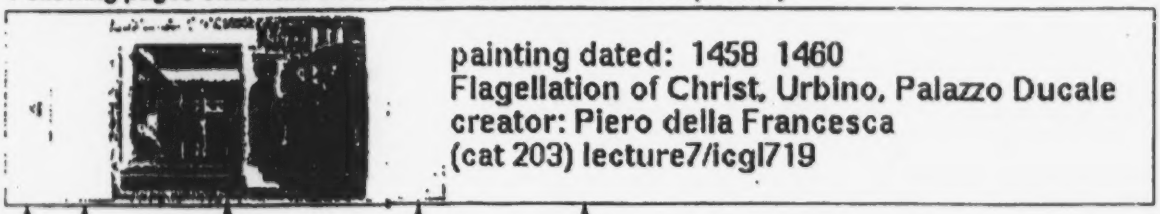
The Artifact Item Layout and Operations

To illustrate the interactions possible at the list item level, we examine the artifact item and its controls. Each item has these visual elements:

- an arrow allowing initiation of the link dialog,
- an indicator showing the level of the item if an item tree is being displayed
- a thumbnail version of a larger image if one exists
- up/down arrows allowing navigation of tree items
- a descriptive label.

Following pages elaborate on the details of each interactive pathway.


painting dated: 1458 1460
Flagellation of Christ, Urbino, Palazzo Ducale
creator: Piero della Francesca
(cat 203) lecture7/icgl719

the label describes the artifact in terms of:
- type, "painting"
- dates, painted between 1458 and 1460
- title: Flagellation (plus some annotations)
- creator (if known): Piero
- catalog id and image file name.

the up/down arrows may or may not be present; only a down arrow is shown here (see example below).

The thumbnail image..

If this item is a participant in an item tree, this shows the level within the tree by the number of chevrons displayed.

The link button, when selected, initiates the link dialog in relation to this item. Initially blue, it is recoloured red when selected, meaning it is the current source item in the dialog.

Here we show the result of selection of the down arrow on the Flagellation. The partial image has the original item with some details showing. Note the "level" indicator telling how far down the tree a particular item falls.

At level 1, the whole painting is displayed

Level 2 shows the scene with the 3 figures. Note; both up and down arrows are displayed.

Part of the above scene is the portrait of an unknown man at level 3.

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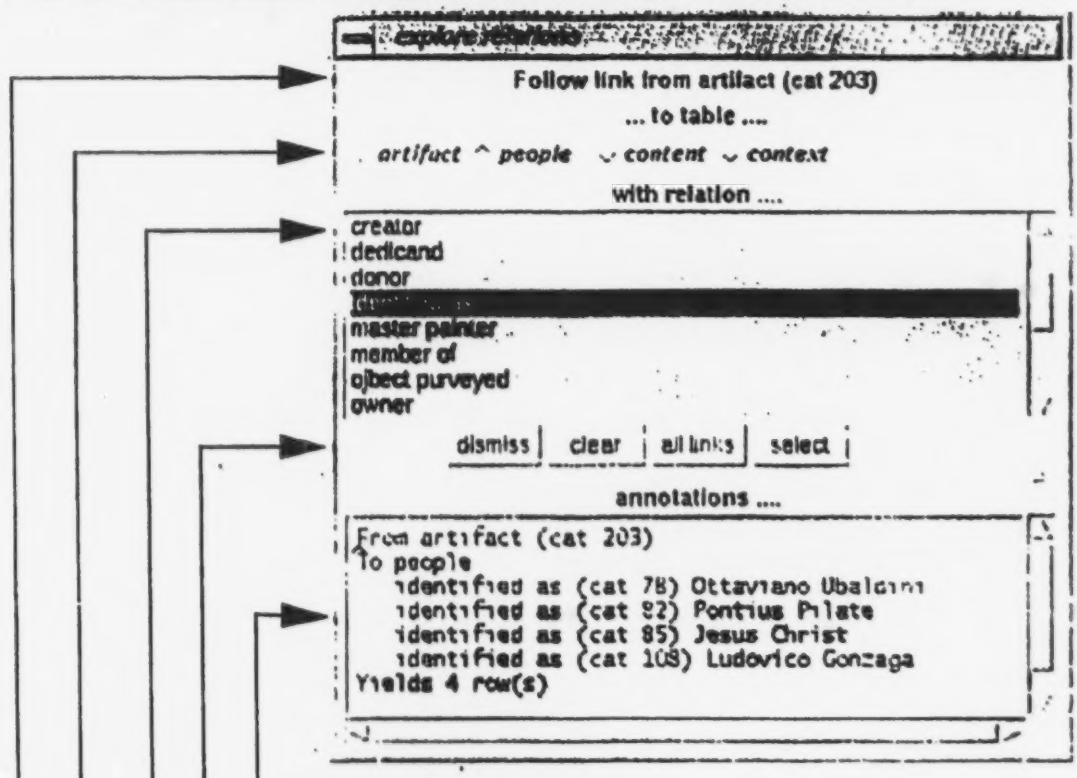
The Link Dialog

In response to selection of the link button on a table list item, the dialog box, shown below, is displayed. We describe here the appearance of and interactions with the dialog.
The visual elements are:

- a label showing the source item and table from which the dialog was initiated.
- a set of buttons allowing specification of the target table, hence the relation set,
- the relation set is displayed in a list from which one or more options may be selected
- control button set:
  - "dismiss" dismisses the dialog
  - "clear" clears any selections made in the relation set,
  - "all links" automatically selects all target items satisfying all relations for the source item,
  - "select" selects all items on the target table satisfying existence of picked relation(s).
- the annotation window informs on target items and relations as found in the database.



The annotation window

Control button set.

The relation set as defined between artifact and people. In this case "identified as" is the selected relation

Allows specification of the target table and, hence, the relation set. "People" is currently selected.

Identifies the source table and item from which the dialog was initiated. The "Flagellation" is the current source item

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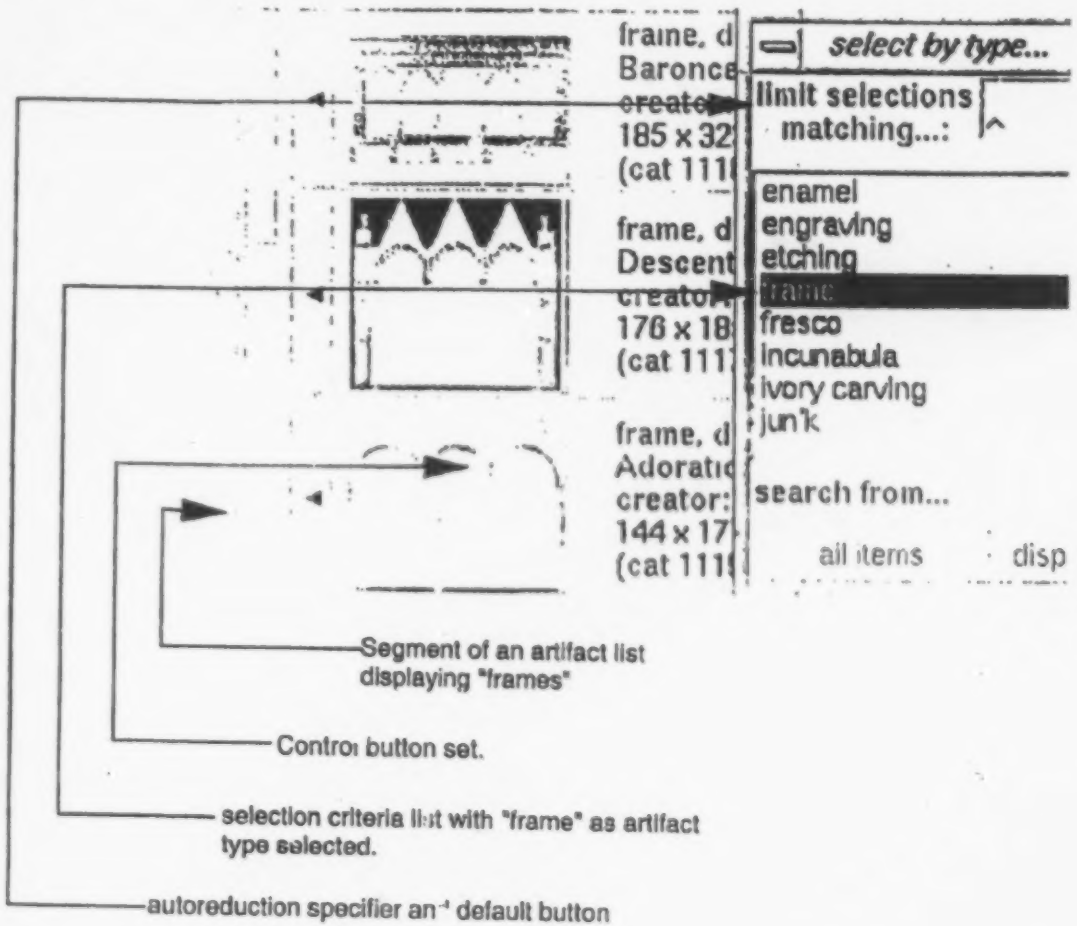
Selection Dialogs

All table panel lists can be constructed based on criteria selected from selection dialogs. Each table panel has its own criteria set.
The example shows a dialog displayed to allow selection of artifacts by "type" along with part of the list resulting from the selection.
The selection dialog has these common visual elements:

- "list item search" an autoreduction feature that allows list narrowing
- "default" button that redisplays the original criteria list if autoreduced
- a selection criteria list allowing multiple picks,
- control button set:
  - "dismiss" dismisses the selection dialog
  - "clear" clears any list selections,
  - "all items" selects items on the basis of picked criteria from the database as a whole,
  - "current" selects items on the basis of picked criteria from the currently displayed list in this table panel.

Other dialogs allow selection of artifacts by artist (primary creator), by date specification and by title keyword.
Similar dialogs provide for selected list construction in the other 3 table panels.



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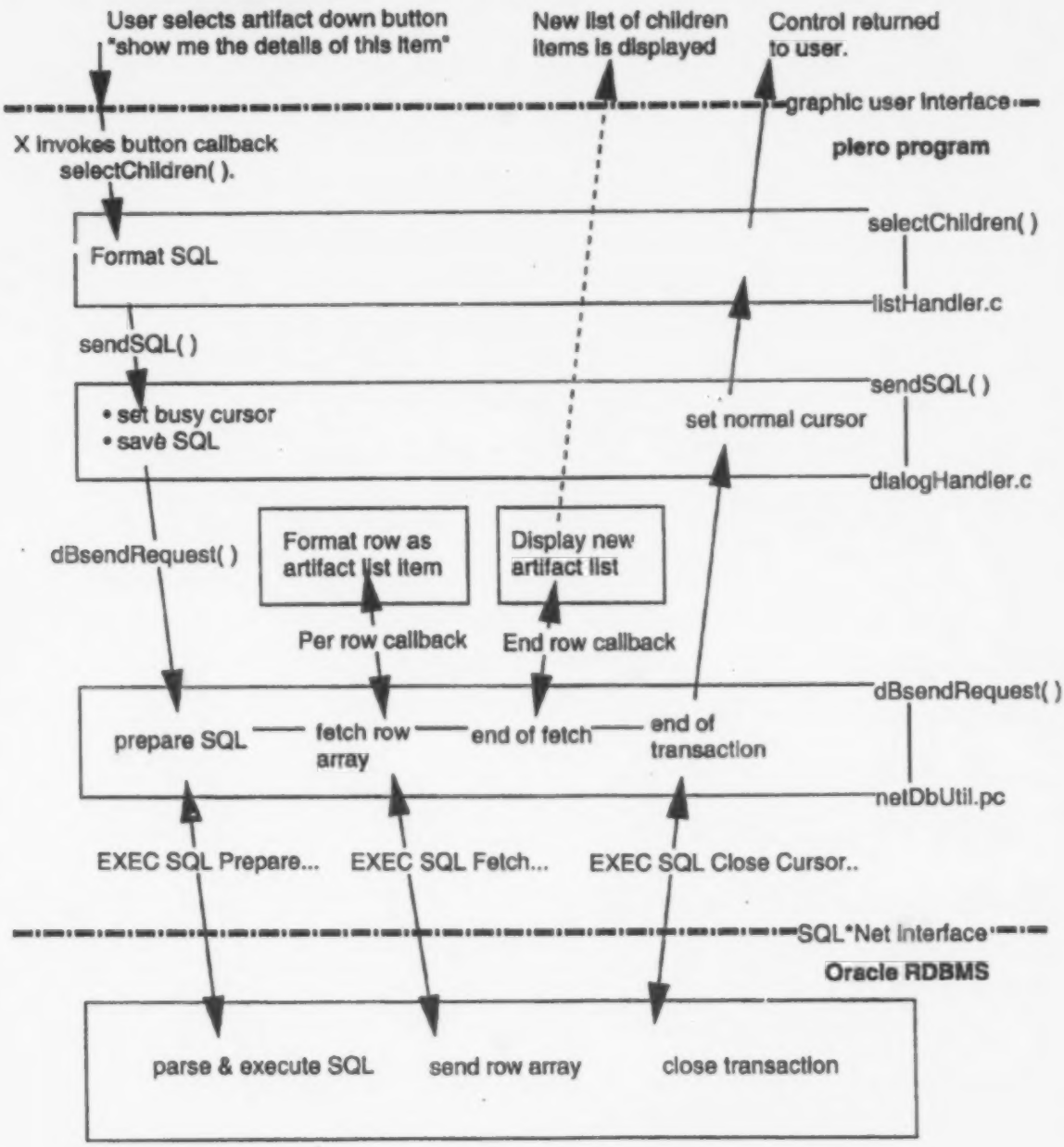
Program Flow (1)

This is an example of the system logic supporting user interaction, via the graphical user interface, with the database. The simplified diagram shows the program flow from the point where the user clicks on the "select children" button in the artifact item, to the point where the children items are displayed and control is returned to the user.
The thrust is

- on catching the user selection, the program uses both the context – the artifact panel – and the item identifier – Piero's "Flagellation" – to format SQL and pass it to the database,
- as the database responds with table rows satisfying the query, to format panel items and then to display them.



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Module Descriptions

- Here we describe:
  (1) how program flow drives the appearance and handles the user interactions within the application, from initialization to exit.
  (2) how user interactions are translated into database queries, specifically, into construction and execution of SQL. Here we choose to provide an instance of SQL formatting rather than a comprehensive description of all such instances.
  (3) with focus on areas of logic/design of particular interest, selection menu generation and handling.....

.c files

piero.c
The initialization driver.

- o Initializes the X/Intrinsics/Motif connection
- o Constructs generic dialogs and the four panel skeletons with their header pixmaps, menus, etc...
- o Initializes application level arguments: the x colormap, verifies initial connection with data base.
- o a timer loop initializes individual panels, menu contents and lists (a timer loop is necessary as, here, we are mingling uninterruptable database processing with Motif panel display. Without the timer delay, incoming data is not synchronized with display of same because of the asynchronous nature of X)

listHandler.c
Populates panel display lists from rows returned from dataBase.

- o other than initialization of menus, all data base queries result in replenishment of a panel's list. Each panel has a unique list item format. This module catches query results and formats list items.
- o a simple caching device allows some performance benefits.

dialogUtil.c
Creates and handles callbacks from selection dialogs and menus.

- o creates search criterion, keyword and date selection dialogs, sets up callbacks and populates search lists from data base. Menu dialogs are all of "multiple selection" type and allow selection from the data base or from the currently displayed list. This feature allows a successive narrowing of the displayed list or a wholesale refreshment thereof.
- o handles SQL, passes to netDbUtil module. The SQL is saved for later qualification (see "narrowing" above) or for re-execution.

ImageHandler.c
Manages all image processing logic.

- o creates and installs X colormap for iconic image display.
- o reads GIF image files, makes X image structures as intermediary to X pixmaps.
- o forks viewer to display full scale image.

netDbUtil.pc
The Pro*C module, hence requiring Oracle pre-processing, that manages the client side data base dialog interface.

- o opens the data base dialog.
- o connects with server data base.
- o catches and executes one or more SQL requests.
- o passes results back to user program at user defined callbacks.

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Modules (contd)

linkHandler.c
Handles all traversal of the database going through the link table.Manages the link dialog, allowing one panel to talk to others.

- o creates link dialog.
- o creates link type selection menu lists from data base.
- o handles dialog invocation.
- o callbacks handle interactions to generate SQL

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